Report of the Proceedings

OF THE

Twenty-Fifth Annual Convention

OF THE

American Railway Master Mechanics' Association

(INCORPORATED)

HELD AT

SARATOGA, N. Y.

JUNE 20, 21 AND 22, 1892

EDITED BY

ANGUS SINCLAIR, SECRETARY

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AMERICAN RAILWAY

MASTER MECHANICS' ASSOCIATION.

(INCORPORATED.)

OFFICERS FOR '92—'93

PRESIDENT,

JOHN HICKEY,

St. Paul, Minn.

FIRST VICE-PRESIDENT,

WILLIAM GARSTANG,

Richmond, Va.

SECOND VICE-PRESIDENT,

R. C. BLACKALL,

Albany, N. Y.

TREASURER,

O. STEWART,

Charlestown, Mass.

SECRETARY,

ANGUS SINCLAIR,

New York.

PROCEEDINGS.

PRELIMINARY.

The Twenty-fifth Annual Convention of the American Railway Master Mechanics' Association was called to order at Congress Hall, Saratoga, N. Y., by President John Mackenzie, at 9 A. M. on June 20th.

At the request of the President, the Rev. G. W. Nicholson engaged in prayer.

An address of welcome was then delivered by the Hon. Mr. Mitchell, President of the village of Saratoga.

President Mackenzie then delivered the following address:

THE PRESIDENT'S ADDRESS.

It is with no ordinary feeling of satisfaction and pride that I greet you in open convention—satisfaction because our organization has existed twenty-five years, and is in a good and healthy condition, as the financial exhibit will show, and because our membership has shown a very large increase since our last meeting; pride because you have seen fit to confer upon me the office of President. We are now an organization composed of representatives of the mechanical departments of nearly every railroad on the continent of North America.

Our prosperity and increase of membership during the last five years have been phenomenal. When we met in St. Paul in 1887 there was a total of 270 members on the roll. Since that time 241 names have been added, making a total membership at this time of 511. We are recognized because, by our perseverance, we have shown to our superior officers that such recognition is our due, from the fact that we have shown a determination to promote their interests by a faithful desire to improve upon and care for the property confided to us in trust. Let us feel greatly encouraged in our own enterprise, and enter upon the work before us with renewed zeal, and a permanent and gratifying success will crown our efforts.

The reports of the various committees, appointed at our last

convention, are in your hands. There has been a steady improvement in the quality of the reports submitted by committees, and this year you will find that the reports are notable for the amount of original investigation represented. Some of the papers are as valuable scientific documents as anything that has ever been submitted to any engineering society. Every member should recognize it as his duty, and esteem it a pleasure, to contribute his mite to the handling of the reports that come before the meeting. Let each one of us, then, endeavor to make the improvement that has met efforts in the past continue in the same strain. It is only by a free interchange of thought, and views openly expressed by a free and candid discussion, that we can attain the objects of our association and arrive at the nearest possible approach to a perfect system of management in the practical workings of the machinery department of railways in detail. We may thus arrive at important and valuable facts and conclusions that cannot be reached through any other channel. I hope, therefore, that none, through modesty or otherwise, will hesitate to give us the benefit of their experience upon any topic that may come before us, or that may be suggested in their own minds.

There is one feature in our organization that I wish to call attention to, and that is our social element, our membership reaching from the Atlantic to the Pacific ocean, and from the Northern Lakes to the Gulf of Mexico.

I am glad to see so many ladies present. I am sure it is a gratification to us, and a pleasure to them, to be here.

Since our last meeting, death has dealt severely with us, seven active and one honorary member having been taken from our ranks. These are: Ross Kells, late S. M. P., N. Y., L. E. & W.; William Turreff, late Assistant S. M. P., N. Y., L. E. & W.; Joseph Bradt, master mechanic N. Y., L. E. & W.; S. D. Bradley, master mechanic Grand Rapids & Indiana; Edward Nichols, president Brooks Locomotive Works; Wm. Smith, superintendent M. P. Boston & Maine; Wm. Wilson, late superintendent of machinery of the Chicago & Alton, and James Sedgeley, an honorary member.

The association is greatly indebted to our Secretary, Mr. Angus Sinclair, for his untiring efforts in our behalf, contributing largely to our success by encouraging the attendance and solicit-

ing new membership. His duties, although arduous, have been executed with ability.

And now, gentlemen, in conclusion I would recommend that we be punctual and regular in our attendance upon the sessions and that all may take an active part in the deliberations of the various subjects that may come before us for consideration.

To you, then, as a body, I now commit this convention, thanking you for your attention and forbearance.

MEMBERS PRESENT AT SARATOGA CONVENTION.

The roll was then called by Secretary SINCLAIR. The following members were present at this and subsequent sessions:

ALDCORN, THOS.,
AMES, L.,
ANTZ, OSCAR.,
ARP, W. C.,
AUSTIN, W. L.,

BALL, A. J.,
BARNETT, J. DAVIS,
BARR, J. N.,
BEAN, JOHN,
BENSON, A. E.,
BLACKALL, R. C.,
BLACKWELL, CHAS.,
BOATMAN, F. P.,
BOON, J. M.,
BOYLE, WILSON L.,
BRIGGS, R. H.,
BROWN, DAVID,
BRYANT, J. T.,
BURNS, C. H.,
BUTLER, L. M.,
BUSHNELL, R. W.,

CAMPBELL, JOHN,
CAMPBELL, JOHN D.,
CASANAVE, F. D.,
CHAPMAN, N. E.,
CLARK, ISAAC W.,
COOPER, CHAS. J.,
COOK, JOHN S.,
CORY, C. H.,
CROMWELL, A. J.,
CULLEN, JAS.,

DAVIS, ED. E.,
DEEMS, J. F.,
DEHN, F. H.,
DERBY, R.,
DOLBEER, ALONZA,
DORSEY, J. B.,

ENNIS, W. C.,

FENWICK, A.,
FORSYTH, WM.,
FOSTER, W. A.,
FULLER, C. E.,
FULLER, WM.,

GARSTANG, WM.,
GENTRY, T. W.,
GIBBS, A. W.,
GIBBS, GEORGE,
GORDON, H. D.,
GORDON, JAS. T.,
GOULD, AMOS,
GRAHAM, CHAS., JR.,
GRIFFITH, FRED. B.,
GRIGGS, ALBERT,

HALL, J. N.,
HAM, C. T.,

HARDING, B. R.,
HARRISON, W. H.,
HATSWELL, T. J.,
HEDLEY, E. M.,
HEDLEY, F.,
HENDEE, A.,
HENDERSON, G. R.,
HIGGINS, S.,
HILL, JAS. W.,
HILL, RUFUS,
HODGMAN, S. A.,
HOFFECKER, W. L.,
HORTON, HENRY H.,
HOWARD, C. H.,

JACKSON, O. H.,
JOHNS, C. T.,

KISSLER, LEWIS,

LAUDER, J. N.,
LAVERY, W.,
LEACH, H. L.,
LEACH, H. L., JR.,
LEE, C. W.,
LEEDS, PULASKI,
LEWIS, W. H.,
LEWIS, WM. H.,
LORD, E. P.,
LOSEY, JACOB,
LUTTGENS, H. A.,
LYTHGOE, JOSEPH,

MACBETH, JAS.,
MACKENZIE, JOHN,
MACKINNON, GEORGE,
MAGLENN, JAS.,
MARSHALL, E. S.,
MAY, EDWARD,
McCREERY, FRANK,
McCRUM, J. S.,
McILWAIN, J. D.,
McINTOSH, WM.,
MEDWAY, JOHN,
MERTSHEIMER, F.
MILLS, STOTT,
MILLEN, THOS.,
MILLER, E. A.,
MILLER, W. H.,
MINSHULL, E.,
MITCHELL, A. E.,
MONTGOMERY, WM.,

NAUFFER, JOHN G.,
NOBLE, L. C.,

O'BRIEN, JOHN,

PATTERSON, J. S.,
PAXSON, L. B.,
PITKIN, A. J.,
PORTER, JOSEPH S.,
PURVIS, T. B.,
PURVIS, T. B., JR.,

QUAYLE, ROBERT,
QUINN, JOHN A.,

RENNELL, THOS.,
RETTEW, C. E.,
REYNOLDS, W. W.,
RICHARDSON, E.,
ROBERTS, E. M.,
ROBERTSON, W. J.,
RUTHERFORD, WM.

SAGUE, JAS. E.,
SCHREIBER, P. H.,
SEWARD, J. P.,
SETCHEL, J. H.,
SHEER, JAS. M.,
SHEERER, E. P.,
SHIELDS, J. C.,
SINCLAIR, ANGUS
SKINNER, H. M. C.
SMART, C. E.,
SMITH, WM.,
SMITH, W. T.,
SOULE, R. H.,
SPRAGUE, H. N.,
STAPF, F. M.,
STEARNS, W. H

STEPHENS, S. A.,
STEVENS, GEO. W.,
STEWART, ANDREW F.,
STEWART, O.,
STINARD, F. A.,
STONE, W. A.,
STOUT, HENRY K.,
STRODE, JAS.,
SUTHERLAND, R. D.,
SWANSTON, WM.,

TANDY, H,
THATCHER, THOS.,
THOMAS, C. F.,
THOMAS, H. T.,
THOMAS, W. H.,
TODD, LOUIS C.,
TOWNSEND, JOS.,
TURNER, CALVIN G.,
TURNER, CHAS. E.,
TWOMBLY, FRED. M.,

VAIL, A.,
VAUCLAIN, SAMUEL M.,
VOSS, WM.,

WADE, R. D.,
WALKER, C. W.,
WARREN, BERIAH,
WARREN, W. B.,
WATTS, AMOS H.,
WELLS, REUBEN,
WHEELER, M. C.,
WHITE, A. M.,
WHITLOCK, JOSEPH,
WHITNEY, H. A.,
WIGHTMAN, D. A.,
WILCOX, W. J.,
WILLIAMS, E. A.

Associate Members.

BARNES, D. L.,
CROSMAN, W. D.,
DEAN, F. W.,
FORNEY, M. N.,
HILL, JOHN A.,
MARSHALL, W. H.,
MILES, F. B.,
POMEROY, L. R.,
SMITH, JOHN Y.

Honorary Members.

DIVINE, J. F.,
JOHANN, JACOB,
THOMPSON, JOHN.

The Secretary's Report.

Secretary Sinclair then read his annual report as follows:

The report submitted by your secretary a year ago showed that there were on the roll 430 active members, 14 associate and 14 honorary members, a total of 458.

On June 1 of this year there were 475 active members, 16 associate and 20 honorary members on the roll, a total of 511. This is a gain of 53 during the year.

If the prosperity and popularity of the association is to be measured by growth in membership, ours has risen very rapidly

in the last four years. There are many men still eligible who are not members, but a little help from those on the list would soon bring the greater part of them to our roll.

During the last year death has dealt heavily with the association; seven active members and one honorary member having been called hence. The active members who died were S. D. Bradley, Joseph Bradt, Ross Kells, Edward Nichols, William Smith, W. F. Turreff and Wm. Wilson. The honorary member was James Sedgeley.

Shortly after last convention your secretary learned that F. E. Worcester, an active member, had died over a year ago. An obituary notice was prepared and published in the annual report then in preparation.

The annual report was printed in the usual form, 1,800 copies having been contracted for. These to the extent of 1,461 were disposed of by sending to the members, to the subscribers to the printing fund, to newspapers, to exchanges and by sales.

The money received during the year amounts to $3,014.50. Of this sum $1,010 was received in the printing fund, $1,960 in dues and $44.50 by sale of reports.

In obedience to a resolution adopted at last convention your secretary applied to the Secretary of State of New York for the incorporation of the association under the laws of that State and the act was duly consummated; so the American Railway Master Mechanics' Association is now an organization having legal standing.

At the last convention a committee consisting of the president, treasurer and secretary was appointed to draw up the necessary legal papers for transferring the Boston Fund to the Stevens' Institute of Technology, Hoboken, N. J., in the purchase of four scholarships for the Association in that institution. The necessary papers were duly prepared and the custodian of the fund paid $8,000 to the president of the Institute, and the contract conferring the scholarships upon the Association was issued and is now in the hands of your secretary. Notice was immediately sent out to the members, advising them of the time of the examination and giving particulars of specimen examination papers. Owing, no doubt, to the difficult examination to be passed, and the short time for preparation, only one candidate entered, viz.: Mr. George Hodgman, son of Mr. S. A. Hodgman. He passed successfully

for the scholarship of the second year and has been a highly creditable student.

As it will take three years to fill the scholarships by the admission of one each year, your secretary consulted with the officers of the Stevens Institute about how an equivalent for the money expended could now be obtained, and they have agreed to admit to the Stevens Preparatory School, scholars equal to the number of the M. M. scholarships vacant. This is an excellent school connected with the Institute, and is used for preparing students for the more advanced institution.

Your secretary has information of several candidates who will compete for the scholarships at the next examination and there is every indication that the number of applicants in the future will be much in excess of the prizes to be gained.

ANGUS SINCLAIR,
Secretary.

The following were the contributions to the Printing Fund:

Atchison, Topeka & Santa Fe	$10 00
Atlantic Coast Line	10 00
Baldwin Locomotive Works	25 00
Baltimore & Ohio	10 00
Boston & Albany	10 00
Brooks Locomotive Works	25 00
Bur. Cedar Rapids & Northern	10 00
Central Vermont	10 00
Charleston & Savannah	10 00
Chesapeake & Ohio	10 00
Chicago & Alton	10 00
Chicago, Burlington & Northern	10 00
Chicago, Burlington & Quincy	10 00
Chicago & Northwestern	10 00
Chicago, Milwaukee & St. Paul	10 00
Chicago, Rock Island & Pacific	10 00
Chicago, St. Paul, Minneapolis & Omaha	10 00
Cincinnati, Hamilton & Dayton	10 00
Cincinnati, New Orleans & Texas Pacific	10 00
Cleveland, Akron & Columbus	10 00
Cleveland, Cincinnati, Chicago & St. Louis	10 00
Colorado Midland	10 00

Columbus, Hocking Valley & Toledo	$10 00
Concord & Montreal	10 00
Connecticut River	10 00
Copiapo Railway	10 00
Cumberland & Pennsylvania	10 00
Delaware & Hudson Canal	10 00
Delaware, Lackawanna & Western	10 00
Denver & Rio Grande	10 00
Duluth & Iron Range	10 00
Duluth, South Shore & Atlantic	10 00
East Tennessee, Virginia & Georgia	10 00
Fall Brook Coal Co.	10 00
Fitchburg	10 00
Flint & Pere Marquette	10 00
Grand Rapids & Indiana	10 00
Grand Trunk	10 00
Great Northern	10 00
Houston & Texas Central	10 00
Illinois Central	10 00
Intercolonial	20 00
Iowa Central	10 00
Jacksonville Southeastern	10 00
Kansas City, Fort Scott & Gulf	10 00
Lake Erie & Western	10 00
Lake Shore & Michigan Southern	15 00
Lehigh Valley	10 00
Louisville, New Albany & Chicago	10 00
Louisville, New Orleans & Texas	10 00
Louisville & Nashville	10 00
Maine Central	10 00
Michigan Central	10 00
Minneapolis & St. Louis	10 00
Minneapolis, St. Paul & Saulte Ste. Marie	10 00
Missouri, Kansas & Texas	10 00
Mobile & Ohio	10 00
Newport News & Mississippi Valley	10 00
New York, Chicago & St. Louis	10 00
New York, Lake Erie & Western	20 00
New York & New England	10 00

New York, Ontario & Western	$10 00
New York, Providence & Boston	10 00
New York, Susquehanna & Western	10 00
Norfolk & Western	10 00
Northern Pacific	10 00
Ohio & Mississippi	10 00
Old Colony	10 00
Pennsylvania	10 00
Pennsylvania & Northwestern	5 00
Philadelphia & Reading	10 00
Philadelphia, Wilmington & Baltimore	10 00
Pittsburg Locomotive Works	20 00
Porter Locomotive Works	10 00
Portland Locomotive Works	10 00
Rhode Island Locomotive Works	10 00
Rio Grande Western	10 00
Rogers Locomotive Works	50 00
St. Louis Southwestern	10 00
St. Louis & San Francisco	10 00
Savannah, Florida & Western	10 00
Schenectady Locomotive Works	10 00
Seaboard Air Line	10 00
Southern Pacific	10 00
Terre Haute & Indiana	10 00
Texas & Pacific	10 00
Toledo & Ohio Central	10 00
Western Maryland	10 00
Western New York & Pennsylvania	10 00
Wilmington & Weldon	10 00
Wabash	10 00
	$1,010 00

On motion the Secretary's report was received.

Secretary SINCLAIR then read the Treasurer's report as follows:

TREASURER'S REPORT.

Dr.

June, 1891—	To Balance on hand, last report	$1,061 75	
" 1892—	Interest	8 01	
" 1892—	From A. Sinclair, Secretary	3,014 50	
	Total Receipts		$4,084 26

Cr.

June, 1892—By	Bradley & Poates, Engraving	$30 80	
" "	R. W. Ryan, Stenographer	167 80	
" "	A. Sinclair, Secretary......	1,200 00	
" "	Wave Printing House, Printing......................	27 50	
" "	*Newark Advertiser*, Printing	602 50	
" "	McGowan & Slipper, "	6 50	
" "	DeLeeuw, Oppenheimer & Co., Printing............	279 00	
" "	*Locomotive Engineering*, Engraving..................	70 50	
" "	Insurance on Reports.......	8 00	
" "	Incorporating Association...	7 25	
" "	Letter Filing Case........	14 00	
" "	Case for Reports...........	18 63	
" "	Postage, Expressage, Telegrams, and other expenses of Secretary's Office......	165 35	
			2,597.83
	Balance on hand......................		$1,486 43

O. STEWART, *Treasurer*.

ANNUAL DUES.

The PRESIDENT—The next business is the assessment and announcement of annual dues. The Executive Committee, which consists of the officers of the association, has deemed it proper to make the usual assessment of $5.00 for each member.

AUDITING COMMITTEE.

The next order of business will be the election of an Auditing Committee.

J. M. Boon, Wm. Lewis and H. N. Sprague, were elected as Auditing Committee.

The PRESIDENT—We are now under the head of new business.

MASTER CAR BUILDERS ELIGIBLE AS MEMBERS.

Mr. J. H. SETCHEL—You will remember last year you ruled in regard to membership that a master car builder was eligible to membership in this association, and as there are persons present who desire to become members of that class, it would be very well, it seems to me, to pass on that before we

do any other business, in order that they may take part in the proceedings of the association.

The PRESIDENT—I would state, Mr. Setchel, that the position the chair took under the constitution is prescribed in Article III, Section I, where it says, "Those above the rank of general foreman, having charge of the design, construction or repair of railway rolling stock," are eligible for membership, and the chair decided that a master car builder could become a member of this association.

Mr. SETCHEL—Our next chairman—it is for the purpose of emphasis that I offer this resolution—our next chairman may alter that. By putting it in the form of a resolution we will fix the matter. The resolution is:

Resolved, That all car builders above the rank of general foreman having charge of the design, construction or repairs of railway rolling stock, are eligible to membership in this association.

The motion was seconded.

Mr. SETCHEL—The constitution says that those above the rank of general foreman, having charge of the design, construction or repairs of railway rolling stock, are eligible to membership. This just simply recites that and makes it binding on the association until this resolution is rescinded.

Mr. H. N. SPRAGUE—I suppose a protest is of no use at present. But I cannot see the relevancy of such a resolution to this association unless we intend to combine the two associations. The idea of calling in here men who know nothing about locomotives, to act on locomotives, seems to me to be absurd. I cannot let such a thing pass without my protest against it. You might as well call in carpenters to deliberate on locomotives as car builders. I think you ought to say master car builders who are also master mechanics. That would not be so bad.

Mr. SETCHEL—This is not a locomotive association; it is railway rolling stock. That means cars and locomotives. There is no way to get around it at all.

The resolution offered by Mr. Setchel was adopted.

DELEGATES TO SOCIETY OF RAILWAY SUPERINTENDENTS.

Secretary SINCLAIR read the following letter from the secretary of the American Society of Railway Superintendents:

AMERICAN SOCIETY OF RAILROAD SUPERINTENDENTS,
Secretary's Office,
350 Atlantic Avenue, Boston, Mass., April 30, 1892.
C. A. HAMMOND, *Secretary*.

ANGUS SINCLAIR, Esq.,
Secretary Master Mechanics' Association,
912 Temple Court, *New York*, *N. Y.*:

DEAR SIR—At a meeting of the Executive Committee of this society held in New York, April 13, 1892, it was voted that the secretary be authorized, in the name of the society, to extend a cordial invitation to the Master

Mechanics', Master Car Builders', Roadmasters' and Train Dispatchers' Associations to send two or more delegates to attend our next meeting and take part in the discussions.

I assure you it gives me great pleasure to extend the above invitation to your association and hope it may be accepted. I have long thought that there should be a closer bond of union between our own organization and those representing the several departments of railroad operation and maintenance, and I can but hope that the step now taken may lead to not only mutual benefit, but to an increase in usefulness in the railroad service as well.

The next regular meeting of our Society will be held October 10, 1892, probably at Hotel Brunswick, New York; due notice, however, will be sent you. As I presume your annual meeting will be held before ours, I should be grateful if you would kindly inform me what action is taken upon our invitation and what representatives you will send to attend our meeting.

Very truly yours,

C. A. Hammond,

Secretary.

Mr. Dolbeer—I move that the letter be accepted and that a committee of two, consisting of the president and secretary of this association, be appointed to attend the Superintendents' meeting.

Mr. Lauder—It seems to me that this is rather an important step for us to take, and I for one would like to have time to think it over before acting upon it. There is one feature of the motion made by the gentleman that I should oppose, and that is naming two delegates. I think the association should select, annually, delegates to meet with the Superintendents' society, provided we see fit to send delegates. Now, wouldn't it be well for this matter to be laid upon the table and let the Executive Committee, perhaps, or a special committee of three or four or five, take it up and discuss it and report later in the session of the association? This is a radical departure. It is something that is sprung on all of us, and I think we ought to think it over a little and be very careful how we act in this matter. I am in favor of sending the delegates, but I am not in favor of making the resolution read that the delegates shall be the president and secretary. I think that we should select annually, or for a term of years—preferably annually—a couple of delegates to meet with them. That is my motion now; but I may change it. I hope the gentleman will withdraw his motion and that the matter may be allowed to lie on the table. I would move an amendment or substitute, if he chooses to accept it, that the matter be laid on the table and that the president appoint a committee of five to take up the matter and report later in the session.

Mr. Dolbeer—I would still adhere to my motion, for the simple reason that I believe this is the first time we have received an invitation from the Superintendents to meet with them. I think it would be in extremely good taste for us to have our representative men—the president and the secre-

tary of this association—there to meet them at the first time that a delegation is sent from this convention. I feel now that it would be better for us to let the resolution stand as it is.

Mr. Blackall—I would state to the convention that the Master Car Builders selected five delegates to attend the Superintendents' meeting. I agree with Mr. Lauder.

Mr. Dolbeer—Under all the circumstances, I withdraw my motion.

Mr. Lauder—I now move that the matter be laid upon the table and that the president name a committee of five to consider it later.

Mr. Setchel—If you lay it on the table, it takes it out of the hands of the committee.

The President—Would it not be better to have it read something like this: That the communication be received and that the chair appoint a committee of five to consider the matter and report later—if you want it that way.

Mr. Lauder—I will put it in that way—that the communication be received and referred to a special committee of five to be appointed by the chair.

The President—You have heard the motion that the communication be received and placed on file, and that a committee of five be appointed by the chair to report later in our session.

The motion was carried.

A committee, consisting of J. N. Lauder, R. C. Blackall, W. H. Lewis, F. D. Casanave and W. H. Thomas, was appointed by the chair to consider the invitation extended by the Society of Railway Superintendents.

This committee reported subsequently recommending that two delegates be sent to the meeting according to the invitation and that they be elected by ballot. The meeting then proceeded to ballot, and J. N. Lauder, Boston, and John Mackenzie, Cleveland, were chosen as delegates.

Proposed Associate Members.

Secretary Sinclair read a letter from George H. Baker applying for associate membership.

The President—I will appoint as a committee upon this application Messrs. Lauder, Swanston and Briggs.

At a later session an application for associate membership was presented for John H. Leeds, signed by P. Leeds, J. M. Whitlock and John Mackenzie. A committee, consisting of O. Stewart, J. D. Campbell and Fred. M. Twombly, was appointed to report on it.

Another application on behalf of Harry P. Robinson was received, signed by W. H. Lewis, Wm. Smith and C. E. Smart. The committee appointed to report on this consists of J. N. Barr, G. F. Wilson and Peter H. Peck.

Committee on Resolutions.

A Committee on Resolutions was appointed, consisting of W. H. Marshall. F. D. Casanave and R. H. Briggs.

Legitimate Business of the Association.

Mr. Setchel—If I am in order, I would like to introduce a resolution involving some new business.

Resolved, That all questions pertaining to the repairs, construction or design of the rolling stock of railways, whether of engines or cars, are legitimate questions to come before this association.

Mr. President, I move the adoption of the resolution.

The motion was seconded by Mr. Briggs.

Mr. Lauder—I favor the adoption of that resolution. I do it with the idea that it will make one thing plain to the members that there might be some question about in their minds under our constitution. It seems to me perfectly plain that the constitution means exactly what that resolution recites, and I think it is eminently right and proper that it should be passed. Then there can be no possible chance for any misunderstanding. I move its adoption.

The motion was carried.

H. L. Cooper for Honorary Member.

Mr. Sinclair—I have a communication here from one of the old members who is now out of the railroad business—H. L. Cooper. He wishes to be made an honorary member.

Mr. Leeds—I move that the name of H. L. Cooper be placed upon the honorary list.

The motion was carried.

Cause of Vice-President Hickey's Absence.

Secretary Sinclair—I had a communication from our worthy First Vice-President, Mr. John Hickey, which I think it is right the members should learn the spirit of. Mr. Hickey has always displayed a very great interest in the business of this association and has been a very regular attendant at the meetings, and he wished me to express his regret that he could not be here at this convention. Since the last convention he has met with a great deal of misfortune in his family. He has lost a very promising son who was expecting to be one of the candidates for the Stevens Institute Scholarship. That happened about six months ago; and about a month ago he lost a daughter, and the family is in much distress over this affliction so that he could not come to the convention, and he wishes that his regrets be expressed to the members under the circumstances.

Secretary Sinclair—There is no more new business.

Exhaust Pipes, Nozzles and Steam Passages.

The President—Then we will proceed to the reading of the reports. The first report is on Exhaust Pipes, Nozzles and Steam Passages.

Secretary SINCLAIR—We have not received that report. Mr. C. F. Thomas, I believe, is prepared to give some explanation.

Mr. THOMAS—On account of some things that have come up of recent date, your committee has not been able to produce the report, and under an agreement with Mr. Gibbs and myself, who saw the rest of the committee in person, we concluded not to submit the report for reasons which Mr. Gibbs can give better probably than I can, as he went over the ground in person with the rest of the committee.

Mr. A. W. GIBBS—I would like to explain that we found out that we were at about the end of our rope in doing our testing. When the Purdue University engine was fitted, we endeavored to have our tests made under constant conditions, so as to make comparative results as to the amount of fuel thrown out and in the draft performances. They replied to us that we could have the use of the engine, but not before September. The other things that came up made us feel that any results we might announce now would be in the nature of guesses, and concluded it would be better not to report at all than to make a report in the nature of guesses. Mr. Thomas has done a good deal of work, and I was to tabulate it, but did not do so. Mr. Thomas is the one member of the committee who has worked on it.

Mr. J. Y. SMITH was understood to say that he had prepared a report upon a branch of the subject, and that he was prepared to read it to the convention.

The PRESIDENT—I do not believe it would be in order to read an auxiliary report without the consent of the balance of the committee.

Mr. SMITH—I sent my report to Mr. Thomas, and Mr. Thomas said I could read this document this morning. I spent a good deal of time and money and I experimented on these pipes for the purpose of bringing this report into this convention.

The PRESIDENT—I should decide that this is not a report of the committee. If the members wish to hear it, it is all right. It is not signed by the committee, as I understand it.

Mr. SMITH—I sent my report to Mr. Thomas, the chairman of the committee. As one of the members of the Exhaust Pipe Committee, I think I have the right to tell the association what I have been doing.

Mr. A. E. MITCHELL—It seems to me that on a report like that, we should have a complete report on the nozzles, so that when the subject is brought up we can discuss it in every direction and at all points, and I move, therefore, that the report be deferred till next year.

Mr. BRIGGS—I second the motion.

The motion was carried.

STATUS OF THE CAR COUPLER QUESTION.

The PRESIDENT—The next report is on the Present Status of the Car Coupler Question.

Secretary SINCLAIR—There is no report in on this subject. At the last

meeting, you will remember, this committee's duties were extended to requiring them to confer with the Interstate Commerce Commission, or represent this association at the meeting of that commission ; and Mr. Forney attended and represented the association in a very creditable manner, and I think probably he might be able to give a verbal report on that subject. Mr. Hickey is chairman of the committee, and he is not here and has sent no communication.

Mr. FORNEY—I would state that I had not expected that the report would be called for so early in the meeting. The report is prepared and I have it in my pocket, but I desire to submit it to one other member of the committee before presenting it. I would prefer to submit the report tomorrow morning.

The PRESIDENT—I think we can pass that order of business and come back to it again. Unless there is some objection, that will be done.

STANDARD TESTS OF LOCOMOTIVES.

Secretary SINCLAIR—The next subject is Standard Tests of Locomotives. Mr. J. N. Lauder is chairman of that committee.

Mr. LAUDER—The committee appointed at the last meeting on standard methods of testing locomotives have no report to make at this time. The reason for this is, that a like committee has been appointed by the Society of Mechanical Engineers, a portion of that committee being members of our association. It was suggested to our committee by them that we hold a joint session and prepare a joint report so as to have our ideas harmonious and make the report of some value. This seemed to me, as chairman of our committee, a desirable thing to do, as reports brought in here that have no value ought not to be submitted, and we might make a report recommending certain standard methods that would be at entire variance with the report of the Society of Mechanical Engineers. After consulting with several members of our committee, it was decided that we had no authority to confer with them with a view of making a joint report, and it was also unanimously decided that we ask this association to continue the committee another year or to appoint a new one, and instruct them to confer with a like committee of the Society of Mechanical Engineers with a view of making a joint report. This seemed to be the best thing to do under the circumstances, and we therefore decided to report on the action we had taken to this convention, and to ask them to continue the committee, or to appoint a like committee another year, and instruct them to confer with the Committee of the American Society of Mechanical Engineers and make, at our next meeting, a joint report. I think I can assure you, that if you take such action, we will make a report next year that will have some value in it.

Mr. ROBERTS—I move that the committee be continued and that it report next year.

The motion was seconded.

The PRESIDENT—The motion as Mr. Lauder wishes to have it put, is

TABLE VIII.

DIMENSIONS OF ENGINES TESTED ON SOUTHERN PACIFIC AND OLD COLONY RAILROADS.

No. of Engine	374 S. P. / 375 S. P.	367 S. P.	71 S. P.	1,787 C. P.	1,785 C. P.	7 L. A. T.	1,536 C. P.	169 O. C.	235 O. C.	232 O. C.
Kind of engine	Simple.	2 Cyl. Comp.	Simple.	Simple.	2 Cyl. Comp.	2 Cyl. Comp.	Simple.	Simple.	Simple.	2 Cyl. Comp
No. driving wheels	8	8	8	6	6	6	6	4	4	4
Diam. driving wheels, inches	51	51	54	69	69	56	57	68	69	69
Cylinders, diam. x stroke, inches	20 x 26	20 / 29 x 26	20 x 30	19 x 24	20 / 29 x 24	11½ / 19 x 24	18 x 24	18 x 24	18 x 24	20 / 28 x 24
Weight of engine, total lbs	133,000	139,000	132,250	127,000	129,700	99,330	113,950	....	97,840	112,000
" on truck, " "	23,300	29,250	23,700	25,500	33,020	27,460	18,750	....	34,630	45,700
" " driving wheels, total lbs.	109,700	109,750	108,550	101,500	96,680	71,870	95,200	....	63,210	66,300
" " " " per ct.	82.48	78.96	82.08	79.92	74.54	72.35	83.55	....	64.6	59.2
Grate surface, sq. ft.	30.82	30.82	25.6	28.6	29.26	16.7	25.38	19.2	19.2	19.2
Heating surface, firebox, sq. ft.	155	155	121.4	....	....	....	129.4	....	....	....
" " tubes, "	1,729	1,729	1,589	....	....	....	1,417.6	......	....	....
" " total, "	1,884	1,884	1,710.4	1,736.2	1,736.2	1,473	1,547	1,262	1,372	1,354
" " per sq. ft, grate	61.13	61.13	66.81	60.7	60.7	88.2	60.96	65.7	71.4	70.5

ception of the features necessary to the compounding. This class of engine had been found suited on the St. Paul road for handling variable business successfully, and was believed to be an economical machine.

In explanation of the form of the report, it was considered desirable to furnish in detail, for purposes of reference, a description of tests, the instruments employed and the checks against error introduced. These details encumber the report considerably, but are given in such shape that they may be omitted in reading to get a general idea of the methods and results.

GENERAL DESCRIPTION OF TESTS.

All tests were planned to show the relative economy of the engines under the wide variations of conditions found in every-day working, the intention being not in any way to interfere with the schedule of the trains on the time card, or the lading resulting from regular handling of the traffic offered. The engines were run as usual, "first in first out," and thus fell to haul local, or extra trains in turn. On March 31st, preparations were completed for the tests, which were accordingly begun and continued for about seven weeks, or up to the time when data was needed for the report, giving in all sixty trips of 92 miles each. Two crews were selected to handle the engines; these were picked out as being careful and observing men, accustomed to work their engines with intelligence and method, and the results proved that a better selection could not have been made. In order, however, to neutralize as far as possible the "personal equation" of the men, the crews were run alternately on each engine, and the results show the handling of both the simple and compound engine with each crew.

A special attendant in the cab was run with each trip, whose duties were to keep the running log, as explained more in detail under special heading.

A dynamometer car built for these tests was run directly behind the engine on each trip. The attendant in charge of the tests remained in this car and obtained the diagram of the pull at the tender draw-bar, from which the foot-tons of train work done on trip were calculated.

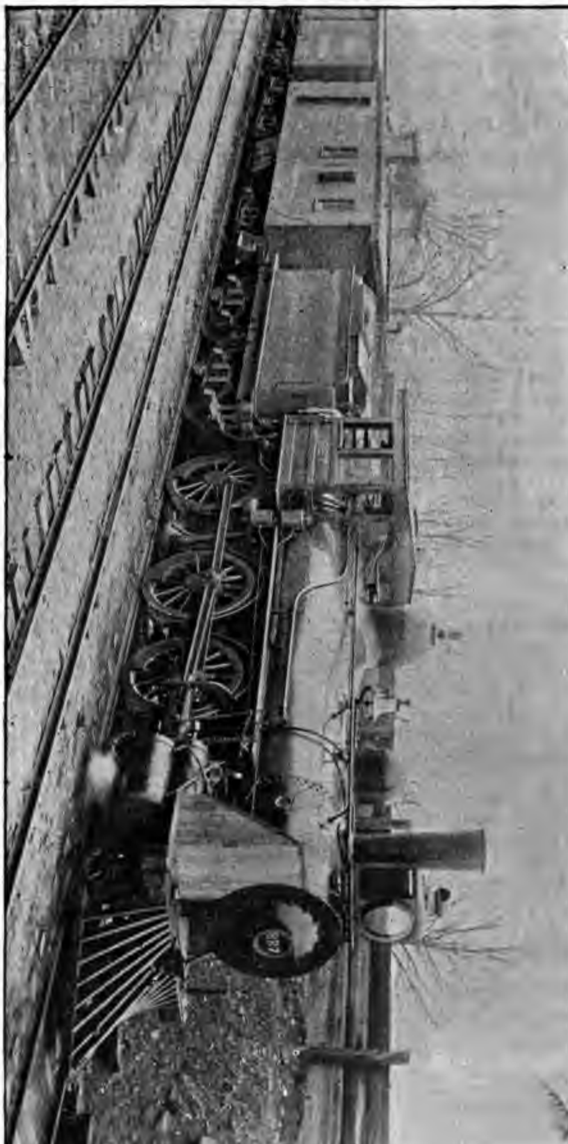


FIG. 1.

DESCRIPTION OF LOCOMOTIVES.

The two locomotives, as shown in general view and in some detail in Figures 1 and 2, were built by the Baldwin Locomotive Works, in 1892, from plans and specifications of the Chicago, Milwaukee & St. Paul Railway Company. The additional dimensions for the two engines are given in the annexed table.

	Compound, 827.		Simple, 822.
	H. P. Cyl.	L. P. Cyl.	
Diameter of cylinders	12"	20"	18"
Stroke of piston	26"	26"	26"
Valves, outside lap	7/8"	5/8"	3/4"
" inside "	0	0	0
" lead	1/16"	3/8"	1/16"
" travel in full gear	4½"	4½"	5 5/16"
Steam ports, width	1 9/16"	1 13/16"	1¼"
" " diameter	9¾"		17½ length
Exhaust port, width	3 15/16"		3"
Throw of eccentrics	2⅝"		2⅝"
Length of eccentric rods	4' 8¾"		4' 8¾"
Firebox, size inside	6' 6" × 2' 10"		6' 6" × 2' 10"
" depth	6' 5"		6' 5"
Grate area	18.4 sq. ft.		18.4 sq. ft.
Tubes, length (between sheets)	13' 7½"		13' 7½"
" diameter outside	2¼"		2¼"
" number	191		191
Diameter of smokestack	16"		16"
" " drivers	5' 2"		5' 2"
Exhaust nozzle, kind and diam.	3⅜" double		3¾" double
Heating surface, tubes	1,576.6 sq. ft.		1576.6 sq.ft.
" " firebox	135.5 sq. ft.		135.5 sq.ft.
" " total	1712.1 sq. ft.		1,712..1sq.ft
Ratio heating surface to grate	9.3 to 1		9.3 to 1
Weight on drivers	87,970 lbs.		86,200 lbs.
" " truck	34,430 lbs.		33,800 lbs.
Total weight in working order.	122,400 lbs.		120,000 lbs.

In working the engines it soon became evident that the compound at 180 pounds pressure was not as powerful a machine as a simple engine at the same pressure. The Baldwin Locomotive Works, when informed of this, stated that they had built the compound to carry 200 pounds, clearly a misunderstanding of the Committee's wishes in the matter, which were to have all the conditions as far as possible identical. The test records will show that the Committee have attempted to remedy this unfortunate

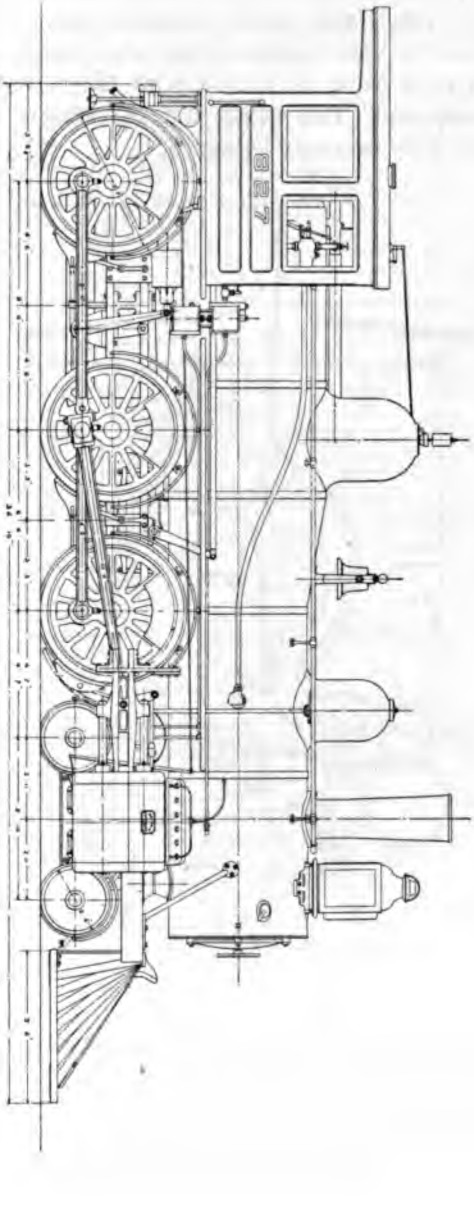


Fig. 2a.

mistake by running both engines at 180 and 200 pounds pressure alternately. The simple engine, however, does not derive the full benefit of this increased pressure, and could not be worked with it successfully on account of trouble with the valves running dry. In the "compound" this defect did not appear, as the piston-valve used is very perfectly balanced.

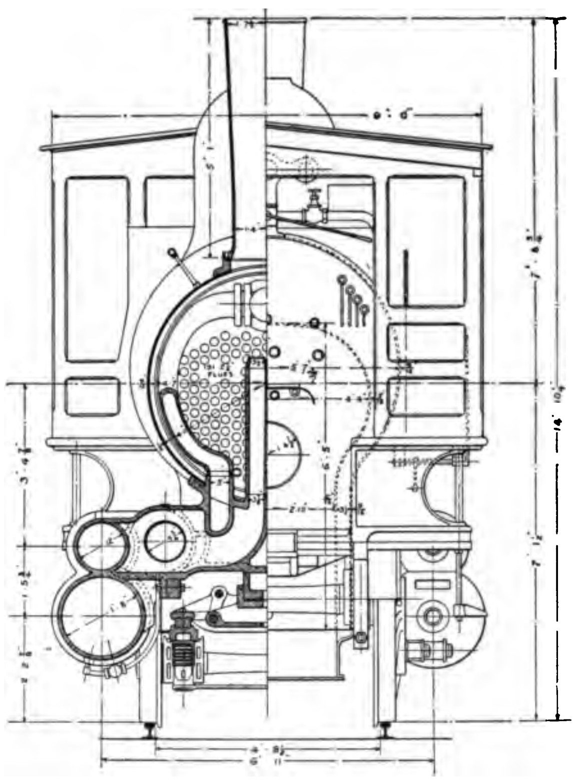
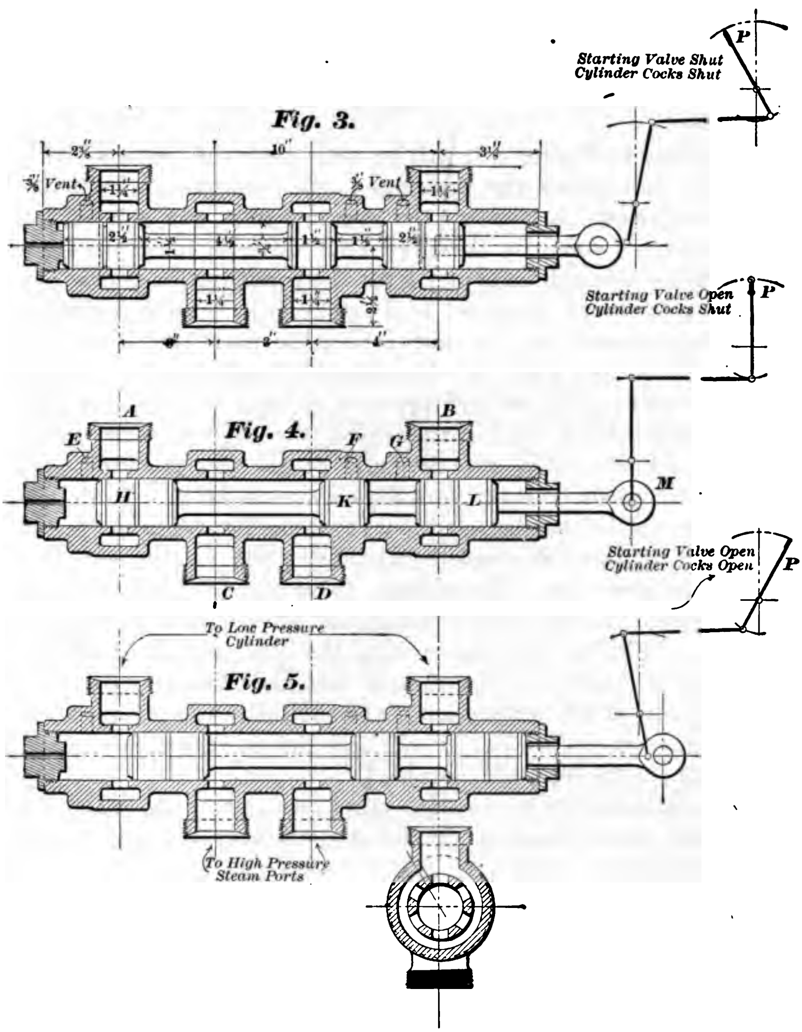


FIG. 2*b*.

Figures 3 to 5 give general plans and details of the Vauclain starting-valve and cylinder-cock rigging. It consists of a casing with a piston-valve inside. The casing is placed below the lower cylinder in the usual position of cylinder-cocks, and the rod of the piston valve is attached at "M" to a lever rigging up to the cab,



FIGS. 3, 4 AND 5.

where it terminates in a handle at "P." This handle has three positions: First, shown in Figure 3, where both starting-valve and cylinder-cocks are closed; second, in Figure 4, starting-valve open, cylinder-cocks still closed; third, in Figure 5, starting-valve and cylinder-cocks both open. The ports "A" and "B" are con-

nected to the drainage ends of the low-pressure cylinder; the ports "C" and "D" to high-pressure steam-ports in the main-valve. The vents for condensation are shown at "E," "F" and "G."

Referring to Figure 3, it will be seen that the pistons "H" and "L" fully cover the openings to the low-pressure cylinder, while the piston "K" covers the opening from one side of the high-pressure; steam is therefore shut off from communication between the two cylinders and from the condensation vents. In Figure 4 the valve is moved half stroke, still, however, covering the low-pressure exits, but uncovering the port "D," throwing the two ports "C" and "D" in communication, permitting steam from the inlet end of the high-pressure cylinder to travel through the starting-valve to the exhaust end of the high-pressure cylinder, and, consequently, into the inlet of the low-pressure, thus mixing live steam with the partially expanded steam. In Figure 5 the piston-valve has traveled to its extreme position and opened the vents of the low-pressure cylinder, while leaving the live steam inlet also open. The starting-valve may be opened without opening the cylinder-cocks, but that the latter cannot be opened without admitting live steam into the low-pressure cylinder. Further, the rigging is so arranged that the starting-valve may be kept open at will for any length of time with the reverse lever in any position. This feature will be found of importance when the results of the tests are discussed.

It is unnecessary to mention other features of the Vauclain compound, descriptions of similar engines having been repeatedly published.

DESCRIPTION OF THE ROAD.

The route selected for the test was the east end of the La Crosse Division from Milwaukee to Portage, a distance of 91 miles. Profile and alignment are given on diagram, on plates Nos. I and II. One-half mile from Milwaukee the heaviest long grade on the line is met, being approximately 47 feet to the mile for 4.5 miles. This grade is the limiting one for weight of west-bound trains. The road from there to East Rio, 77 miles from Milwaukee, is an undulating succession of short grades and level stretches; from East Rio to Portage, a sharp descent of eight

miles is encountered. For east-bound trips the limiting grade is found between Wyocena and East Rio. This grade is the worst on the division, but being shorter than the "Soldiers' Home" grade, and in a position admitting a "run for the hill," is easier surmounted than the latter.

NATURE OF THE TRAFFIC HAULED.

The trains consisted of mixed classes of "freights" in both directions, the west-bound trips having a larger proportion of light-loaded cars and empties than the east-bound, where compact and heavy trains were furnished.

DETAIL DESCRIPTION OF THE TESTS.

These were made in a series extending from the 31st of March to May 22d, inclusive, sixty complete single trips in all, with dynamometer car. The engines were run on the "first in, first out" plan, handling all classes of trains in succession. The special features of the tests are described in detail under the appropriate sub-headings below:

First—Dynamometer Car.—This car, the inside mechanism of which is shown in Figure 6, was built for the purpose of these tests, being somewhat modified from plans kindly furnished by the Chicago, Burlington & Quincy Railroad Co. The general views of the exterior and interior of the car are given. The apparatus contained in the car consists of the well-known arrangement of recording apparatus, which measures continuously the compression of the draft springs and traces the same (line D, plates III and IV) by a pen in contact with a continuous roll of paper, which is kept in movement by a geared connection to the car axle. The car wheels imparting motion to this apparatus were turned with cylindrical bearing surface on the rails, so that the speed of rotation of paper on the registering drums was exactly proportional to that of the car, irrespective of end play of the axles. Sample records obtained from this apparatus are shown in plates I, II, III and IV.

The speed of train was obtained by means of another pen, attached to the armature of an electro-magnet and drawing a line (line A, plate I) on the paper; at intervals of five seconds impulses were sent through this magnet from an electric contact on a clock, and caused the pen to jog inwards and make a dash at right angles to the straight line; the distance between these five-seconds dashes, measured in sixtieths of an inch, gave the speed of car in miles per hour.

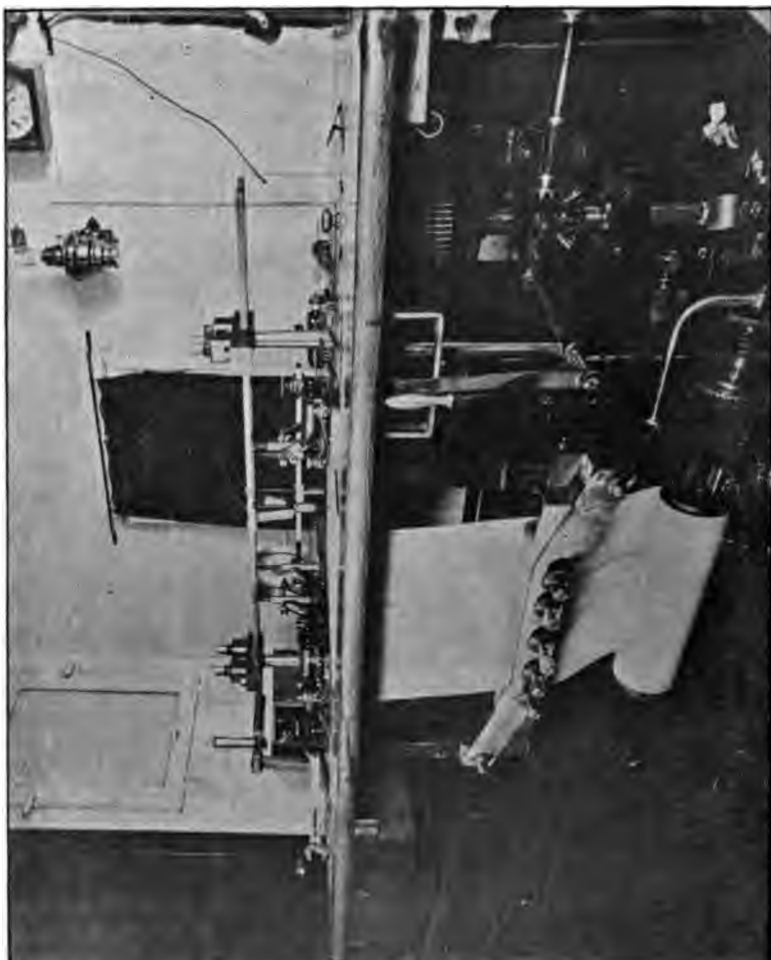


Fig. 6.

The location of mile-posts, stations, etc., on the diagram (line E), was obtained by means of another pen, similarly connected to a magnet and caused to make a jog in the line when the attendant pressed a push-button at the window. The position of the reverse lever in cab was registered on the diagram in car (line B) in the same manner, by pressing push-button giving con-

nection with the cab by a cable. The datum line (line C), from which the height of stress-diagram was measured, was drawn by a fixed pen, adjusted to be coincident with pen A when the latter registered the position of zero pressure on the draft springs. When indicator cards were taken, an additional marking pen was adjusted on the paper, and was arranged to give a mark when electric contact was made at the indicator in taking a card (line F). The main stress-diagram obtained on the moving paper, was on scale of one foot to the mile.

The number of strokes made by the air-pump was registered in dynamometer car by means of electric impulses sent from the contact apparatus, shown in Figure 7, attached to the loco-

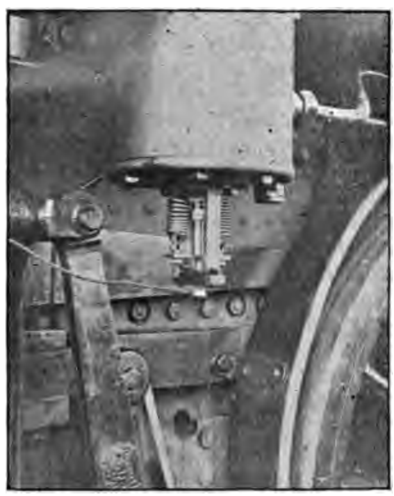


FIG. 7.

motive air-brake pump. This recording device is substantially a clock movement, in which the balance wheel or pendulum has been removed, and the escapement operated by the pull of a magnet armature; movement of this escapement turned the hour and minute hands, and the number of double strokes of air-pump were in this way measured by reading off the differences in time registered during the trip, multiplying the same by movement of hands for one stroke. The amount of steam (or water) consumed per stroke was taken as one-tenth pound, a figure determined by experiment and kindly furnished by the Westinghouse Air-brake Company. This figure is somewhat less than the actual weight

of one cylinder full of steam at given boiler pressure, which fact is accounted for by wire-drawing in passages, etc.

Further communication between locomotive cab and dynamometer car was established by an electric bell and speaking tube.

Measurement of Fuel.—The arrangements for determining the total amount of coal shoveled into the fire-box during the trip were very complete. The method followed was that first brought to our notice by Mr. D. L. Barnes, and was found to work exceedingly well in practice, being accurate and quick, a matter of great importance in trips following each other rapidly. About ten gunny-sacks were filled with dry coal to an accurate weight of 250 pounds each. These were stacked in the rear part of the tender, to be used only when the loose coal was exhausted. The tender was then filled with coal to an amount which was closely figured to the requirements of the trip. This coal was weighed by the barrow-full on a platform scales and dumped into a chute, from which it was loaded on the tender. This method removes the point of greatest inaccuracy, incident to the ordinary method of weighing the tender entire. The weighed coal was not allowed to be touched until the moment of beginning the test proper, that is, at the time of leaving the terminus with the train. Coal for firing-up in roundhouse and making up train was taken from extra bags provided for the purpose. In starting the fire was brought up to a pre-determined standard height in box, from the unweighed coal, and at the end of the run was left in same condition with *weighed* coal. After a few trips it was found possible to gauge quite closely the amount of loose coal needed for the trip, the aim being to use as few of the weighed bags as possible and yet to have little loose coal to weigh off the tender at the end.

Measurement of Water.—The feed-water used was determined by means of two "Two-inch Low Capacity" Thomson water meters, one attached to each side of the engine, in the suction-pipes of the injectors. Check valves were introduced between the meters and the injectors, to prevent hot water blowing back and injuring the hard-rubber recording discs of the meters. The number of cubic feet of water used was read on the dials. In addition to the meters, a tank-float was also used as a check; but after a number of trips its continued use was abandoned, as it could not compare in accuracy with the meter readings, and was of value only as a rough check. The meter readings were taken just before starting from terminus with train and immediately after arriving, the water level in boiler, as read on gauge glass, being in both cases brought to standard, when engine stood on level track.

Measurement of Steam Pressure.—A novel method for this purpose was followed in the use of an Edson "Steam Pressure

Recording Gauge." This gauge constitutes an exceedingly convenient piece of apparatus, and although subjected to unusually severe conditions on a locomotive, worked properly after the necessary regulation. The diagram furnished was, however, on too small a scale (one inch equal to one hour running) for anything except a general idea of steaming conditions ; it could undoubtedly be easily modified to give any desired scale. In taking indicator diagrams, the boiler pressure was observed in the usual manner by an attendant in the cab.

Measurement of Speed.—This factor was determined, as explained in the description of the dynamometer car, by two methods, the improved Boyer Speed Recorder, and the electric contact marks on the stress-diagram paper. Examples of the Boyer record will be found on Plates I and II. Scale of record was one-half inch to one mile run. For a locomotive test, it would be desirable to have the record enlarged to, say, two inches to the mile.

Measurement of Dryness of Steam.—For this purpose a calorimeter was used on four trips ; no record, was, however, taken on the remaining trips. The instrument was a copy of one devised by Mr. Barnes and described fully by him in the *Railroad Gazette* of November 27, 1891. It was attached at the rear of the steam dome and designed to show the priming at the point where the steam enters the throttle valve. Probably a better location would be in the steam pipes at the cylinder saddle, where the quality of the steam supplied at the main valves would be indicated.

Measurement of Injector Overflow.—For this figure, injector was put on for a number of times, say fifty, and the overflow caught and waste per time averaged. Improved Sellers injectors were used, and the overflow from these was found to be not only a quite constant quantity, but was much less than from the old Sellers pattern. Deductions from this loss were, of course, made from the water record of the meters.

Measurement of Waste at Pop-Valves.—Two three-inch pops were used on the dome. The waste from these when blowing off was found to be a surprisingly large quantity. Its amount was determined by causing the valves to pop for ten minutes and taking measure of the water used. In order to keep steam pressure up for this purpose, the engine was fired up and blown by an extra blower pipe led into front end from stationary boiler. The locomotive boiler was first filled to standard height on gauge glass, and after test refilled through the meter. The quantity blown off as above was found to be not less than three boiler gauges, giving an average of 168 pounds water or steam wasted per minute popping.

Measurement of Vacuum in Front End.—This figure was obtained for four trips by means of a glass U-tube gauge in the cab

connected by a $\frac{3}{8}$-inch iron tube to the front end, about the center line of boiler and opposite the nozzle.

Temperature of Front End.—A Weiskopf pyrometer was used for this purpose, running into the smoke-box and located above the netting.

Cut-off and Throttle Opening.—The cut-off was taken at the reverse lever notches, which were calibrated from the valve setting. The throttle opening was not determined, as this figure is a very indefinite one at the best.

Indicator Diagrams.—Four trips were made on which diagrams were taken; a large number were obtained with both engines working in all positions of reverse lever, throttle and speed; also at all prominent changes of physical conditions of the road. The Crosby indicator was used, and a view of the parallel motion rigging and piping is shown on Fig. 8. This rigging was devised by Mr. W. H. Elliott, and is the most convenient one for use at high speeds which your Committee has seen.

Persons Employed on Tests.—The Chairman of your Committee had general charge of the arrangements for the tests; Mr. W. H. Elliott, assistant to M. E. of C., M. & St. P. Ry., had general charge on the road and ran the dynamometer car records. Messrs. William and George Mason, assistants in mechanical department of C., M. & St. P. Ry., ran each a round trip in turn on the engines, keeping the log of the trip, including the coal and water measurements, cab observations, description of the train, weights of cars, etc. Mr. F. L. Allcott, in charge of C., M. & St. P. test room, was clerk of the tests, keeping and tabulating all records as fast as received. A large force in the draughting room was engaged in working up the dynamometer car records and checking the results. These last records constituted the most arduous portion of the work, which may be readily seen when it is considered that sixty trips of 100 ft. of record paper each had to be measured up with a planimeter and foot-tons of work and other data deduced therefrom.

Manipulation of the Engines.—As before stated, no attempt was made to interfere with the usual manner of handling the trains; the usual number of delays on road were encountered and engines were worked to make up lost time when possible, as is customary in every-day practice. An attempt was made—and successfully—to select for the crews careful and observing men, who ran their machines with method and intelligence. No better proof of this was needed than an examination of the economical results shown on tables, and the carefulness of the firing evidenced by examination of the steam pressure diagrams and time of blowing steam at pop-valves. In many trips the boiler pressure was well kept up to the maximum, and yet *no* steam was blown off, an extraordinary record in freight service, considering that

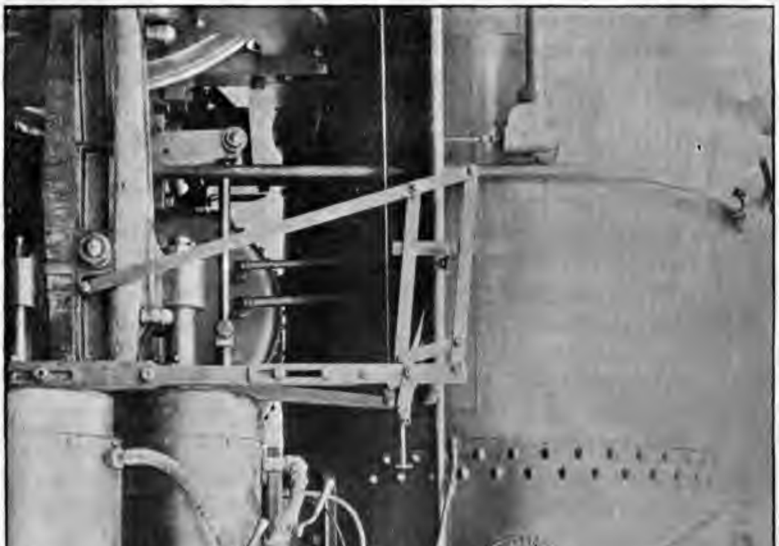


Fig. 7.

On pages 43 and 44 are shown sample indicator cards from the two engines tested. These were selected from the large number taken to lilustrate the steam distribution under different conditions of cut-off, speed and steam pressure. The table on page 42 and the table below contain the particulars of these indicator diagrams. The only diagrams which are of special interest are compound diagrams Nos. 1 and 2, which were taken when the starting-valve was in use and which show clearly the effect of this valve.

A feature of the Vauclain type of compound locomotive which has been generally criticised is the difference between the total steam pressure on the high and low pressure pistons, which tends to rock the crosshead and, hence, induce additional stresses in

DATA TO ACCOMPANY INDICATOR CARDS FROM NO. 822.

No. of Card.	Boiler Pressure.	Revolutions per minute.	Cut-off, Mean.	Mean Eff. Pressure.	Total I. H. P.
1	166	122.	16.2	95.74	770.1
2	176	61.	12.5	106.6	428.7
3	170	133.	8.9	76.12	667.4
4	186	142.	8.9	67.11	628.2
5	173	223.5	7.	51.72	763.7
6	180	195.	5.1	48.54	623.9
7	196	86.8	10.7	124.9	716.5
8	190	111.7	8.9	68.38	504.8
9	197	182.9	7.	66.95	807.7
10	194	168.	5.1	20.69	227.5
11	200	203.3	5.1	45.89	614.1
12	197	243.9	5.1	40.85	657.1

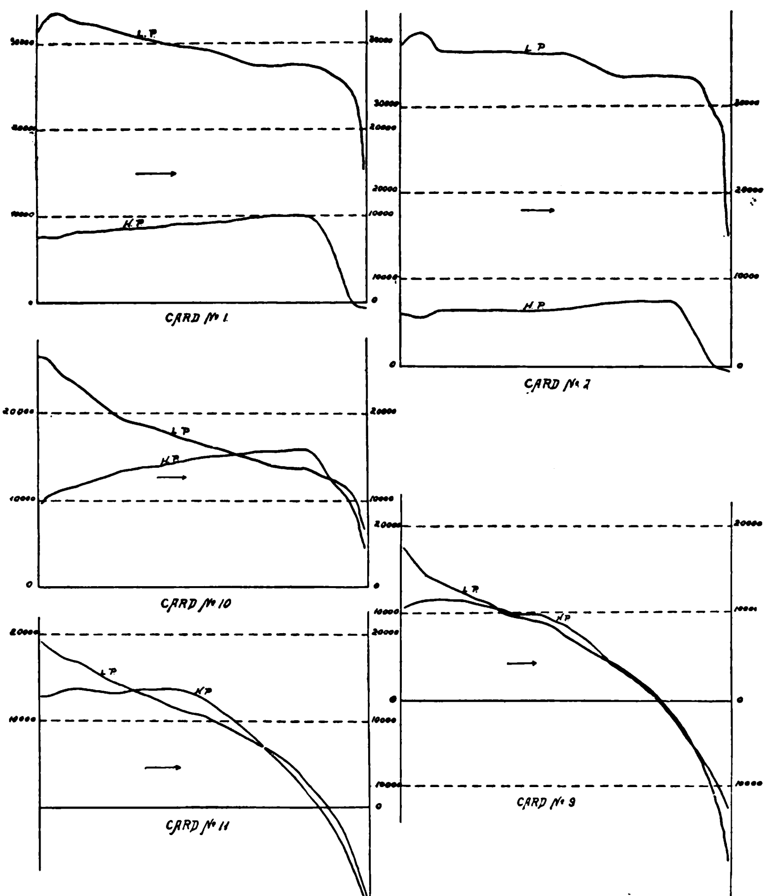
the piston rods. To show what this amounts to in some sample cases, the diagrams on page 47 were prepared. The numbers of the indicator cards from which these diagrams were prepared are given with the diagrams. The ordinates of the curves marked L. P. show the total effective steam pressures on the low-pressure piston, and the ordinates of the curves marked H. P. show the same for the high-pressure piston. The effects of inertia are not considered in these diagrams. Referring to the diagrams for cards Nos. 1 and 2, taken when the starting valve was in use, it will be seen that the greater part of the work was being done in the low

pressure cylinder, as was of course to be expected. The data recorded on the original cards show the conditions to have been the same for the two cards, excepting a difference of one pound in the boiler pressure. The reason for the difference in pressure for the two cards is therefore not apparent.

Card No. 10 shows an excess of about 16,500 pounds on the low-pressure piston at the beginning of the stroke, which is gradually reduced until there is an excess of about 2,200 pounds on the high-pressure piston; the pressures are equalized again toward the end of the stroke. Cards 11 and 9 show a similar crossing of the pressure lines, the greatest difference being about 7,000 pounds in Card 9 at the beginning of the stroke. The indicator cards for this and the following diagrams were selected by your Committee as being good representative cards for different speeds and cut-offs, and may therefore be taken to represent the performance of the engine as fairly as can be done by a few cards.

Much has been written concerning the supposed greater uniformity of the rotative pressures in two-cylinder compound locomotives, as compared with simple locomotives. In order to determine how well this claim is substantiated in practice, the diagrams shown on Plate A were prepared under the direction of a member of the Committee. These diagrams show the combined rotative pressures on the crank-pins of a simple engine, a two-cylinder compound and a Baldwin compound for 100, 150 and 240 revolutions per minute. In preparing the data from which these curves were plotted, the total net effective pressure on the pistons was first taken from the indicator cards for every 10 degrees during one stroke, or one-half revolution. From these pressures were deducted the pressures necessary to accelerate the reciprocating parts, the formula used being the approximate formula given by Prof. Jacobus, in Volume XI of the Transactions of the American Society of Mechanical Engineers. The resulting pressures are those actually transmitted to the crank-pin. The tangential components of these resulting pressures were then calculated and plotted as ordinates on the diagrams shown, thus obtaining the actual rotative pressures for one side of the engine. These are shown by the unlettered curves on the diagrams. Finally the two sides, cranks at right angles, were added together, giving the lettered curves on the diagrams, the ordinates of which repre-

sent the total rotative pressures exerted at a radius equal to that of the crank. For the Baldwin compound cards 10, 11 and 9 were selected; for the simple engine cards 1, 4 and 12, and for the



Total Pressures on Pistons.
No. 827.

two-cylinder compound the cards shown on page 49 were selected from the blue prints of sample cards from Schenectady engines furnished by Mr. H. J. Small. The full-line curves *a a a* are

from the Baldwin compound; the broken-line curves *b b b* are for the simple engine, and the dash-dot curves *c c c* are for the Schenectady compound. The straight lines represent the *average* rotative effort in each case. It will be seen that for the steam distribution used for 100 revolutions, and with the weights of reciprocating parts as built, the simple engine gives a much more uniform pull than the others. Also, that if the compounds were reduced to the same average pressure, the variation would be nearly the same in both. At 150 revolutions, the four-cylinder compound gives the smoothest line and the simple engine is somewhat better than the two-cylinder compound. At 240 revolutions the four-cylinder compound shows the least variation and the simple engine the most. These facts are further illustrated by the fol-

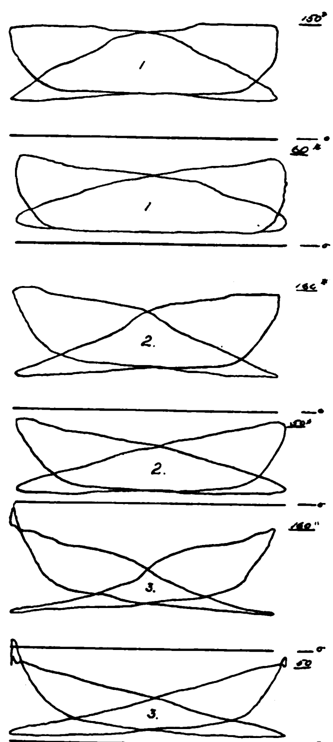
VARIATION IN ROTATIVE PRESSURES.

No. of Engine.	18½ Miles per hour. 100 Revolutions.		28 Miles per hour. 150 Revolutions.		44½ Miles per hour. 240 Revolutions.	
	Maximum above Mean.	Minimum below Mean.	Maximum above Mean.	Minimum below Mean.	Maximum above Mean.	Minimum below Mean.
827	15.1	18.2	10.1	10.2	21.0	25.0
822	5.0	6.0	15.9	22.2	33.3	43.3
1785	14.9	16.5	25.7	22.8	27.1	41.7

lowing table, showing the proportional variation of each engine above and below the mean pressure. It is clear from this, that in this case, at least, the rotative effort or turning movement of the two-cylinder compound is not more uniform than that of other locomotives. There is also evidently a definite combination of steam pressure, cut-off, weight of reciprocating parts and speed for any locomotive with which it will develop its most uniform pull.

As showing in an interesting way the character of the oscillations due to the above (but somewhat modified by irregularities of the road), Plates III and IV have been prepared. These give each three 3½-mile sections of the dynamometer diagram paper, and were photographed direct; the record is, therefore, exactly

as drawn by the apparatus, with the exception of the letters and figures. The middle sections on each plate are taken at same location on road with each engine, and being at about the same speed, show clearly the characteristic oscillations from each. A study of these plates will give an idea of all characters of diagrams produced by the engines at all speeds. Engine 827 gives a steady



Indicator Cards from Eng. 1785 C.P.

diagram up to 22 miles per hour; from 22 to about 48 miles per hour the vibrations are excessive, and at higher speeds again become more uniform.

Engine 822 gives at moderate speeds a much steadier diagram than the compound, having, however, at speeds between 25 and 30 miles per hour, an unsteady period, as with the latter. The

results shown on these diagrams, it is believed, give a more comprehensive idea of the characteristic behavior of the engines in pulling trains under all conditions, than the partial ones shown by the graphical analysis of certain indicator cards, taken at particular points only. It is certain, in any event, that there could be no mistaking the identity of a dynamometer diagram.

TESTS ON OTHER ROADS.

Although the foregoing tests were made with one type of compound engine, your Committee do not wish the results to be taken as establishing the fact that fuel and steam economy may only be expected by the use of that particular type; they have no data at hand tending in any way to an indication of this kind. The use of the two-cylinder type probably involves, in certain cases, a limiting value for the cylinder-volume ratio one, smaller than is the case with the Vauclain type. Whether this limit is one likely to seriously affect the economy and usefulness of the two-cylinder compound or not, is a question your Committee do not feel justified in entering upon at present. They regret, however, being unable to report having made tests with other types, and in view of the absence of such tests submit some results kindly furnished by the officers of other roads. The tables Nos. 8 and 9 contain these results in condensed form, together with the principal dimensions of the engines tested. Profiles of the sections of the road on which the tests were made are also shown. Extracts from Mr. Small's letter accompanying the report of these tests, are as follows:

"The tests made include the following engines: No. 375, Southern Pacific, 12-wheel simple; No. 367, Southern Pacific, 12-wheel compound; both engines the same in every respect excepting the compound feature. One set of tests shows results for a certain number of round trips between Sacramento and Truckee and return. Profile of this piece of road is shown on blue print T–1–107. Figures are also given for a single trip, Sacramento to Truckee, on which the work was nearly all done on a 116-foot grade. This print also shows result of test between same compound engine and engine No. 374, Southern Pacific, simple 12-wheel, in every respect the same as the 375, between Bakersfield and Los Angeles, a portion of which is 174-foot grade; profile of this piece of road is also given. Also between same engines on level track between Bakersfield and Tulare. I have also inserted on this print the result of a test made with engine 71, Southern Pacific, 12-wheel simple engine, with boiler too small for

modern practice; also, Union Pacific engine No. 1,301, with Wootten boiler, which we borrowed for the purpose. This statement also covers a test made between engine (Central Pacific) 1,787, simple 10-wheel passenger, and (Central Pacific) 1,785, compound 10-wheel passenger, both engines the same in every respect except the compound feature. In these tests is also included a Baldwin 10-wheel compound, No. 7, belonging to the Los Angeles Terminal Railway, which we borrowed for the purpose. This Baldwin compound was at considerable disadvantage, compared with the Schenectady engines, from the fact that it had smaller cylinder capacity, was lighter in weight, and had considerable smaller wheels, so that the relative value of the two compound engines should not be considered wholly from this test. The print shows another test, however, between the Baldwin engine, No. 7, Los Angeles Terminal, and No. 1,536, Central Pacific, a 10-wheel simple engine built at Sacramento shops. This test was made in freight service. These two engines were more nearly equal, and we all fully expected better results from the compound. I send indicator diagrams of such of the above engines as were taken.

"These tests were all very carefully made, a competent man being at all times in charge of each engine. All cars were weighed on scales, coal carefully weighed on and off engines, and water measured by means of glass gauges on sides of tank, tank capacity having been ascertained by use of a meter. Every care was taken to have the results accurate and conclusive."

In the same tables are given the results of tests of a Dean two-cylinder compound locomotive on the Old Colony Railroad.

Mr. Frank Hedley sends the following summary of the performance of two-cylinder compound and simple locomotives on the Kings County Elevated Railway:

"Kings County Elevated Railway Co., Brooklyn, N. Y., Frank Hedley, master mechanic. Results of tests made in the month of April, 1892, engines in 'rapid transit' passenger service, making fifty-two (52) stops at stations, in every fifteen (15) miles run.

"Engine No. 63, two-cylinder compound, built by Rhode Island Locomotive Works. Cylinder 12½" and 20" x 16" stroke, Forney type, with a four-wheel swinging truck. Engine loaded ready for service, weight twenty-seven tons. Miles run, 4,875. Anthracite coal (broken size) consumed per mile run, twenty-nine pounds.

"Engine No 21, single expansion, built by Rhode Island Locomotive Works. Cylinder, 12" x 16" stroke, Forney type, with a four-wheel swinging truck. Engine loaded ready for service, weight twenty-five tons. Miles run, 4,894. Anthracite coal (broken size) consumed per mile run, thirty-five pounds.

"I have twelve engines built from the same specifications as engine No. 21 ; they were doing the same work during the month of April, and the general average was forty-four pounds of coal consumed per mile run. Engine No. 21 was picked out of forty-two engines doing the same service, she being the most economical simple engine.

"Thus: The Compound Engine No. 63 runs with 17 per cent. less fuel than engine No. 21, and 34 per cent. less than the general average."

Referring to the tables, it will be noted that the twelve-wheel Schenectady compound No. 367, when tested against simple engines Nos. 374 and 375, of the same make and general dimensions, gave a saving in coal of from 7.38 to 14.84 per cent. and a saving in water of from 6.24 to 13.68 per cent. per ton-mile. The greatest saving is shown by the tests between Sacramento and Truckee, in which a large proportion of the work was done, as shown by the profile, on a grade of about 116 ft. per mile. On the return trip, down grade, the saving was evidently very small, as shown by the figures for the round trips.

As Mr. Small points out, the Baldwin compound was at a considerable disadvantage, and it is but fair to add that on individual trips on which the two train loads were nearly the same for the two engines, the compound makes a much better showing.

The distribution of the work between the cylinders of the two-cylinder compound locomotives in these tests, is given on the sheets of sample indicator cards furnished by Mr. Small, as follows:

PERCENTAGE OF TOTAL WORK DONE IN HIGH-PRESSURE CYLINDER.

No. 361.				No. 1785.			
Cut-off.		Revolutions.	Per cent. of Work, H. P.	Cut-off.		Revolutions.	Per cent. of Work, H. P.
H. P.	L. P.			H. P.	L. P.		
23	23	60	40.3	20¼	20.5	30	45.0
21½	21½	96	40.4	19½	19.7	50	45.8
20½	20½	120	39.3	17½	18.3	60	46.5
20½	20½	108	39.2	15¼	16½	144	47.8
19½	19½	120	37.8	12½	14⅛	180	51.0
19	19	156	36.6	12½	14⅛	240	49.7
19	19	180	32.1	10¼	12⅜	240	48.5
17⅛	17⅛	192	31.	10¼	12⅜	300	52.7
17⅛	17⅛	240	29.5	10¼	12⅜	330	48.5

In a letter of later date Mr. Small sends prints and description of a device invented by Mr. F. W. Heintzelman, M. M., at Sacramento, for equalizing the work done between the high and low-pressure cylinders. The device consists essentially of an attachment to the ordinary valve-gear, arranged to give a differential cut-off in the cylinders.

The Old Colony tests are interesting for comparison with those on the Southern Pacific, and on account of the comparative excessive quantity of coal and water used by the simple engines per ton mile.

Mr. R. H. Soule, of the Norfolk & Western, and Mr. John Hickey, of the Northern Pacific, sent reports of tests of the Baldwin compounds on their respective roads, but as these reports have already been made public through the press, your Committee did not think any useful purpose would be subserved by their repetition here.

REMARKS ON THE RESULTS OF TESTS.

Your committee has felt considerably embarrassed in attempting to give a full analysis of data obtained, for the reason that it involved a more careful study of the figures than they have had an opportunity for. The tables were only completed in the final form at the time the report should have been in the hands of the printer, whereas a complete study of the results provided enough work for many days. It is hoped, however, that the explanation given of the tables is sufficiently full to enable others to study them at their leisure and provide information for future committee work. A hasty examination of the general averages will give the impression that they are so much at variance as to make definite conclusions impossible, and in this connection attention is again called to the few remarks regarding locomotive tests in general, which will be found at the beginning of this report. That, however, valuable data of a more comprehensive nature than generally obtainable is given by these tests, is considered certain by your committee. The condition which will be considered of first importance by railway managers is ability to handle a varying traffic with certainty and economy ; this involves a relative consideration of first, interest account on first cost ; second, the monthly repair bills ; third, the monthly fuel and small supplies bills. It is

therefore apparent that averages must be sought and that individual trips are only of importance in fixing the economical range of the engines, and thus enabling us to figure out the best proportion of parts.

Comparisons can be made on two bases, the coal and water consumed per ton hauled one mile, or on the amount of work done per unit of coal and water. The first will be found on Table No. 7, grouped under "Train Results;" the second under "Dynamometer Results." These last are considered the more exact for comparison, and of these preferably, the figures for coal and water per horse power hour, which not only give results based on total amount of work done, but include the speed factor or *rate of doing work*. As showing the reason for this conclusion, attention is called to Table No. 7, lines 24 and 37, from which is seen that the saving of coal per ton-mile by the compound on east-bound trips, is 3½ times that on west-bound trips, while the saving in coal per horse power per hour is in the ratio of about 1½ ; on the west-bound trips (see Table No. 3) the train consisted of twenty-nine loaded and two empty cars and weighed 583 tons, while east-bound, twenty-six loaded and seven empty cars weighed 754 tons. Differences of like nature will be found in other trips, and the number of loaded and empty cars is therefore no indication of the work actually done.

Two important divisions of the tables are those giving results with use of Braceville and with Pittsburgh coal. The former may be considered a fair example of good Western coal, used by roads in the territory west of Chicago. The main portion of test was therefore conducted with this coal. In order, however, to test the steaming qualities of the engines with the best sample of Pennsylvania coal, it was decided to make a few trips with Pittsburgh coal.

Much has been said about the characteristic exhaust obtained from the compound locomotive, in the two-cylinder compound especially, there is obtained one pulsation of exhaust to two in the simple engine. The character of this pulsation as observed by the sound of the exhaust and by the vacuum in front end, is very different from that of the simple engine, and tests with the two cylinder compound, previously made, had shown a certain percentage of steam economy obtained, and an *additional* percentage of

fuel economy, indicating that the softer exhaust was in some way responsible for more efficient combustion. In the four-cylinder compound, while the pulsations are of the same number as in the simple engine, it was thought the difference in volume of steam discharged from low-pressure cylinder and its lower average terminal pressure, might exert a similar action on the fire, so that while the compound might show fuel economy with the free burning clinkering Western coal, it might give very different results with the hard Pittsburgh coal. It is, further, well known that on account of the clinkering properties of the Western coal to successfully burn it and prevent clogging of the grate-bars, a sharper exhaust must be used than is needed for the non-clinkering Eastern coal. It, therefore, seemed reasonable to suppose that the softer exhaust in the compound would operate to disadvantage in burning the Western coal; hence the results shown in tables are somewhat unexpected.

Referring to column 38, Table No. 1, it will be seen that the size of the nozzles used for the two engines was different. The C., M. & St. P. Ry. standard nozzle is double, 3¾ inches diameter, and has been carefully designed to produce the best steaming with the kind of coal employed.

The compound originally fitted with this nozzle did not steam freely with Braceville coal until the nozzle was reduced to 3¼ inches. With Pittsburgh coal it could be enlarged to 3⅜ inches, but no more.

The effect of using Pittsburgh coal in the two engines is shown in the following table, which gives the percentage of economy so obtained in each engine as compared with its performance with Braceville:

Engine No.	Coal per H. P. hour.	Water per H. P. hour.
822 (simple)	28	9.2
827 (compound)	19	6

It is thus seen that in changing from Braceville to Pittsburgh coal, the improvement in economical performance was greater with the simple than with the compound engine.

In the opinion of your committee the explanation of the greater improvement of the simple engine is that with the friable Braceville coal its sharp exhaust as compared to that of the compound, caused a considerable proportion of the fine coal to be drawn

through the flues unconsumed. With the harder Pittsburgh coal this did not obtain to so great an extent in either engine, and it necessarily follows that the gain from suppression of waste would be more marked with the simple engine, as is shown in the table.

As a consequence your committee feel justified in predicting that in future trials the greatest gain in compounding will be found where coals used are of a dusty or friable nature.

Referring to tests with Pittsburgh coal, and to the column for saving of coal per H. P. hour, it will be observed that where both engines were tested at 180 lbs. pressure, the results show a very slight economy for the compound. Examining tables from which this figure is obtained it would appear that the engines were working under almost similar conditions; the only explanation of the result which your committee has to offer is that for this steam pressure and train the compound was overloaded, and this opinion is strengthened by the figure shown in line 28, where the simple was worked at 200 lbs. and the compound still at 180 lbs.; in this case it will be seen that the percentage of compound economy is negative—in other words the simple was the more economical of the two.

It is but fair to say that in the opinion of your committee the performance of the compound will in prolonged practice be better than above shown, were it worked at its economical steam pressure.

Referring to line 24, where both engines were worked at 200 lbs., the economy is 6.1 per cent. Examination of train conditions will show that all were reasonably within regular service limits and therefore would seem to fairly represent what may be expected with this class of fuel under average conditions. It will be observed, comparing results with each engine with itself at the two pressures, that, while the simple engine shows at the higher pressure a gain in economy of 6.2 per cent., the compound shows a gain of 10.8 per cent. This, it is thought, explains the apparently abnormal increase of 11.9 per cent. of compound at 200 lbs. with simple at 180 lbs., as shown in lines 25 and 26; but it is not to be understood that in their opinion the simple engine will really gain in economy throughout by raise of pressure—at least this conclusion cannot be substantiated by these tests.

As a final average economy with such fuel, it is their opinion

that line 22 should be thrown out, leaving the average economy west-bound as 6.1 per cent. and east-bound 9.2 per cent., or a final figure of 7.6 per cent.

It seems probable, as a general review of the entire question, that the results given with Pittsburgh coal represent the simple engine at its most favorable condition. On the other hand, they are strongly of the opinion that the large number of trips represented by the tests with Braceville coal quite nearly approximate the condition laid down as most desirable at the outset of the report, that is, *average* monthly or yearly economy, to be derived from compound engines. This figure is shown to be 16.9 per cent. coal and 14.1 per cent. water economy.

Signed by Committee,

GEORGE GIBBS,
WM. H. LEWIS,
PULASKI LEEDS,
JAMES MEEHAN.
F. D. CASANAVE,
A. T. WOODS.

DISCUSSION ON COMPOUND LOCOMOTIVES.

The PRESIDENT—Gentlemen, you have heard the reading of the report of your committee on the compound engine. What is your pleasure? I would also suggest that the secretary be authorized to make any changes that Mr. Gibbs, as chairman of the committee, would suggest in printing the report.

On motion of Mr. J. S. MCCRUM the report was received.

Mr. A. W. GIBBS—I notice some tables on the walls, prepared by the committee, which throw a great deal of light on the subject of tests, in a very convenient form. I move that Mr. Gibbs be called on to explain them, as it will save a great deal of time in studying the report.

The motion was carried.

Mr. GEORGE GIBBS—Perhaps, Mr. Chairman, I had better explain what those are first. The results of trips of the engines are shown, of course, in the tables, but it is very difficult sometimes to keep in your mind the results in a long column of figures, and the plotting of results on a piece of paper, showing their relative position to each other at a glance, is exceedingly useful. We succeeded in getting only two tables finished, on account of lack of time, and they were done here and are not in very handsome form. The one of the water—all the trips were made with both engines, with Western coal, are shown plotted there in their relative position to each other, That position is represented in this way. The horizontal line below repre-

sents the weight of the train and engine in tons. The vertical line represents the train-work done as obtained from the dynamometer and it is plotted in terms of foot-tons of work done per pound of water evaporated. That does not take into account the work done in the engine. That figure we did not know how to ascertain. The blue line is the compound and those little dots represents the location of each one of the trips made. Take that trip just up at the top there which is singled out for comparison. You will see by running your eye up the line of 550 tons, that is taken with a train of about 570 tons weight. That gives the vertical position. The horizontal position is taken by looking at the table. So that is about 47 tons of work per pound of water evaporated. The others are obtained in the same manner. So those points represent on that table the water economy or cylinder performance of the two engines, and their position in relation to each other for the same weight of train gives the economy of the engine. You will note that through those colored points we have drawn two dotted lines. That is an attempt to represent an economy curve for the two engines at the different loadings. That is made in dotted lines, only because the points did not fall in a smooth curve and we were not certain of the location. We need more points to determine that. But there are enough points to fix that position as being nearly correct. In fixing it further, we have considered each of those points in turn and looked over the tables to determine whether that particular trip represented average conditions all through. For instance, the trip is No. 18. That trip is much more economical than any other obtained with the compound engine, and obviously does not represent an average result. The reason for that extraordinary economy is shown by reference to the tables. That train, if I remember rightly, was a through, light train with no stops. I think it was made on Sunday with a clear track, and the conditions were very favorable, so that the engine was working at the most economical speed and cut-off. There was no switching done. It was, therefore, a very economical train-load.

On the simple engine, down on the middle of the table, there is an oscillating trip there. That we also threw out for the reason that it was a way-freight that did a large portion of the work in switching. If then those curves represent fairly the position of the average trip at any one point of loading, it will be seen that the compound engine is not only more economical than the simple one but that it holds its economy better.

We take two other curves headed "Coal." I will say here that we cannot expect those results to be as nearly correct as the others, because the errors in the cylinder and in the furnace are added to those. Here you have the weight of the train and engine in tons, and here is the dynamometer train-work foot-tons per pound of coal. These curves have been carefully thought over and put in there. If they are anywhere near right, the compound engine is more economical, simply because the economy rises more rapidly. The point of maximum is reached in the two engines at the same point, and it falls off a trifle less rapidly in the compound than in the simple engine. One cause of the discrepancy in those compounds is this: In the

report it is stated that the weight of the train is no exact indication of the amount of work done. Here we have taken that as a basis. But there are so many variables coming in there that it is almost impossible to expect a close coincidence.

Mr. J. N. BARR—Will those lines represent the economy of the performance of the engine at the same steam pressure?

Mr. GIBBS—They do not. They represent the two steam pressures mixed in there irrespectively. That curve for water represents the Pittsburgh coal performance. In this we could not put in Pittsburgh coal. Those points look quite far apart, but if you will remember that at the base of this diagram is the zero line, the percentage of variation is not so great as at first glance would appear.

Mr. BARR—This is a very important subject, and the committee has discovered a great many things that are not settled yet. In view of the large amount of valuable work which they have done, and the importance of these facts that are unsettled and the manner in which they have been impressed on the minds of the committee, I make the motion that this committee be continued for another year.

The motion was seconded and carried.

Mr. A. DOLBEER—There are several representatives here of locomotive builders—from Brooks, the Baldwin, the Schenectady, the Rhode Island Locomotive Works, and others—and I would suggest that for our information they be requested to give their views in the matter. (Applause.)

The PRESIDENT—Mr. Vauclain, will you please enlighten us upon this subject?

Mr. S. M. VAUCLAIN—I have been called upon to open up the discussion on compound locomotives on the part of the locomotive builders. You will all remember that when I was at the last convention we had quite a long chat upon them, and at that time I tried to inform you of the state of the art, so far as the Baldwin Locomotive Works were concerned. At that time I told you we had taken orders for upward of forty compound locomotives. We had seventeen built and delivered of the type which your committee have examined on the Chicago, Milwaukee & St. Paul Railroad. I then told you that if the demand for compound locomotives kept up at the same rate, that before the end of the year we should have taken orders for one hundred compound locomotives. I am happy to say to you that before the end of the year came we had taken orders for one hundred and sixty compound locomotives, and at the present time we have over two hundred compound locomotives in service, and we have a number under construction at our works. This, I believe, is four or five times the number of compound locomotives that have been built by all others in the United States up to the present time.

The test that has been made on the Chicago, Milwaukee & St. Paul Railroad has been a very extensive one. In fact it has been a crucial test of compound locomotives, and it should settle forever that there is an economy in compound locomotives. The percentage of economy that is given

the discrepancy in these compounds is this: In the

could fire at all. The cylinders are 24 x 28. The boilers are 76 inches in diameter, and they are reported as doing the work of two consolidation locomotives on the grades where they are running. We have built for high speed service this type of compound locomotives. We offered to build the New Jersey Central Railroad a locomotive and put it in service for two months, and if, at the expiration of that time, they had any objection to it, they were at perfect liberty to send it back to our works and we would not say anything at all about it. At the expiration of two months they sent us a check for the engine with a request for four more engines of the same kind. And so I might go on from one railroad to another throughout the United States. The Norfolk & Western bought five ten-wheel passenger compound engines for heavy service, hauling nine coaches over an average grade of about 80 feet to the mile. The Philadelphia & Reading Railroad have at the present time twenty-seven of these locomotives in service on their road, and I believe that it is due to this railroad company to say that they have taken the proper method of determining whether there is any value in compound locomotives. They seem to have bought these locomotives with a view to getting at the facts in a substantial manner as to the kind of economy they can get from them. If Mr. Paxson is present he can be called upon to tell what those engines are doing at the present time. I beg to say this in regard to the economy that was reported from the Chicago, Milwaukee & St. Paul Railroad in regard to Pittsburgh coal. These engines are running on a railroad that have used a Western coal. They burn nothing else but Western coal and their engines are drafted for that purpose. They take the same engines and put Pittsburgh coal on, with the same grates, the same pipes, netting, etc., and they get different results You will notice also in the reports that there is a difference in the water economy of those engines per ton of train hauled, according to the dynamometer tests. I cannot see why there should be any difference in the water per horse power given out in either type, and that goes to prove more conclusively than anything else the disadvantage that any one is at in making locomotive tests in arriving at satisfactory results in regular train service. If you gentlemen are desirous of having a copy of the reports that we have received from other railroads, we have compiled them in a handsome volume and you can get it as you pass out of the room. As they were gotten up entirely for your information we thought this would be the best way to distribute them. As a great many people have asked me, as I go throughout the country, to explain our locomotive to them—it being boxed up in sheet iron, no one can see it—I thought it worth while to write a short description of our method of compounding, and I have also taken the liberty of suggesting a system of making laboratory tests of any locomotive you may see fit to test. A bound pamphlet of that sort is also ready for distribution, along with a copy of locomotive tests. I am ready and willing to answer any question that any member of this association may see fit to ask me.

The PRESIDENT—I will ask if Mr. Pitkin, of the Schenectady Locomotive Works, is in the room. If he is, we would like to hear from him.

Mr. A. J. PITKIN—I simply wish to call attention to the report sent to Mr. Gibbs by Mr. Small giving the equalization of work in the two-cylinder compounds believing as we do thoroughly in the two-cylinder compound engine as being a case of the survival of the fittest. By reference to the table on the thirty-fifth page you will find the distribution of the power in the two cylinders is quite variant. Since building this engine, which is one of the earliest, we have overcome that difficulty, and in later cards we have an equalization of power which is very nearly perfect. We have a description of the two-cylinder type which I would be glad to furnish to any one who would like it. Cutting off at the various points, we have at full stroke a variation of power of only 2.5 per cent in the two cylinders; at 17-inch cut-off, a variation of only 2.17; at 13, 2.54; in no case a variation of three per cent. So that this, we think, will silence all the criticism about our engines wobbling by excessive pressure on one side.

We went into the compound engine business, first, simply as an experiment, because we believed from the results we saw obtained abroad that there was undoubtedly great economy to be obtained therefrom. We have sold three compound engines under solicitation, two of those going to the Michigan Central and one to the Pennsylvania for their limited train between Philadelphia and Pittsburgh. Out of fifty-five or sixty compounds which we have built, these are the only three that we have sought to build, and the others have come to us directly from the roads. In a number of instances where the question has been raised whether we would recommend the compound, we have said decidedly, "No. Here are the results. You can take the compound, or the simple engine, as you please." Possibly we may be a little selfish, because we have built all the simple engines we could possibly build during the last year and could not turn out as many compounds, perhaps. But we are getting special tools in and will be ready to build the engine that is to come.

Regarding the different types of compounds, it is simply a case, as I said, of the survival of the fittest. Simplicity is the main point to be sought for. We think that the two-cylinder type is the simplest type that can possibly be obtained, and we get a sufficient rate of expansion to give good economical results, the economy varying from 15 to 30 per cent., according to the varying conditions of service; this in comparison with simple engines of identically the same design. I would be pleased to answer any questions that may be asked.

Mr. JOSEPH LYTHGOE—We have built quite a number of compound locomotives. We are not advocating them strongly. If people want them, we build them. We think we have a good type. We build a two-cylinder type. We are making a good showing on all the engines that we have running. They are doing very satisfactory work, making a saving of anywhere from 15 to 37 per cent. I do not think there are any of them that are running with less than 15 per cent. in saving. We have just received a report from the Brooklyn Elevated Railroad which is not in this report of Mr. Gibbs, where they have three of our engines and

are running those engines in competition with twelve others of exactly the same type. The engines I speak of were changed over from the simple to the compound. They have been running them against twelve other engines for some months. They have run 15,000 miles on that road, which means several months' service. In that report which comes from the railroad company, and with which we had nothing whatever to do—we had no one there to see it made — they claim a saving of 27 per cent. against the twelve engines for the time run. They do not give the time that it took them to run the 15,000 miles, but it must have taken them some months. As I said before, we are ready to build compound locomotives. We have one passenger engine running on the New York, Providence & Boston. I believe Mr. Butler, of that road, is here, and I have no doubt that he can tell you something about the performance of that engine. We have also built some four-cylinder engines of the Johnstone type, and we are building ten more of that pattern now, some of them for the Mexican Central Railroad and some for other roads. Mr. Johnstone reports that the engines are working in a very satisfactory manner and showing very good economy. I believe Mr. Barnes has been conducting some tests of those engines, and I would like to hear from him as to how they are getting along.

Mr. D. L. Barnes—I have a telegram that my engineer of tests from Mexico has arrived in Chicago. He finds considerable saving with those engines—15 to 30 per cent., as near as he can estimate, the record not having been worked up. The Mexican Central is a road that is well adapted for the compound locomotives. Coal ranges in price from $18 to $22 per ton. The saving per year for a compound engine, on the basis of the results obtained from our experiments, is about $15,000 per engine. On some sections of the road they use wood. The wood has to be carried over the mountains on the backs of mules, and it costs considerable by the time it reaches the road.

The President—Mr. Tandy, can you enlighten us any on the compound locomotive?

Mr. H. Tandy—The Brooks people have been so busy building simple engines that, as a matter of fact, they have not given that time and attention to compound engines which they otherwise would have done. But for our own satisfaction we did build a compound engine of the two-cylinder type and placed it upon a road with the understanding that if they desired they could purchase it at the expiration of six months, and, as they did so, I presume that is evidence that the engine gave satisfaction. This engine has been running in freight service since last September, and has quite recently been put in pretty severe passenger service on trains that will average from ten to fourteen coaches. The engine, so I am told by the railroad officials, has been effecting a saving of from 27 to 32 and 33 per cent. We are also building a compound engine of the four-cylinder type, for our own satisfaction simply, and we are vain enough to think that we shall get quite as good results from that as we did from the other one. I think that the

question of compounding is so well understood by all master mechanics that it is not necessary for me to advocate either one type or the other. This question has been thoroughly discussed and earnestly looked into by all these gentlemen, and I expect that they will now be inquiring for compound engines, and the Brooks people are ready to build compound engines of any type when called upon to do so.

The PRESIDENT—If Mr. Dean is present we would like to hear from him.

Mr. F. W. DEAN—I think, possibly, it would be rather more in order for Mr. Lauder to talk about the compound locomotives that I have been associated with. I think Mr. Lauder had better begin it, and then if there is anything to add I will try to add it.

I would say with reference to that engine, that it is substantially the Old Colony type of engine. That is to say, those alterations have been made which were necessary to make it a compound engine. It is of the two-cylinder type, and it has a cylinder ratio of 1.97 to 1; that is rather unusual; that is to say, the high-pressure cylinder is unusually large. Before the engine was tried I had some misgivings in regard to the proportion being a good one. The cylinders are 20 and 28, and I regretted somewhat that they were not 19 and 28. But after trying the engine, I think the sizes were wisely chosen, and if I were to design another engine I certainly would adopt just about that ratio.

Mr. F. D. CASANAVE—We have had no experience with compound locomotives on our road so far, having had only four or five, which are scattered over a large territory, and we have very few figures to show the economy. From somewhat imperfect trials which we have made of one compound of one type we have found an economy of about 5 per cent. in fuel. There is no doubt, from all the figures shown, that there is economy in compounding and that the economy will be greater where the price of coal is larger, but it seems to me that one of the essentials is to confine the compound locomotive to the simplest form. That matter of repairs is one that must be looked to in order to ascertain whether any saving in fuel will not be absorbed by it. The compounding of locomotives is certainly in its infancy. If I were to take the money out of my pocket to equip a railroad I hardly think I would go very extensively into compounding. I would wait for a year or two until it is clearly shown where the range of economy lies. (Applause.)

Mr. L. B. PAXSON—We have upon the Reading Railroad some twenty-seven compound engines. They are of three types; one type is for working on our mountain grades, pushing coal up, that were built to be the equivalents of consolidation engines of 22x24. We have ten engines for fast freight service that were built to be the equivalents of 20x24, and we have five passenger engines that were compounded to be the equivalents of our 21x22 engines. Now we have not, for certain reasons, attempted to make any scientific tests of these engines. We put them to work alongside of simple engines doing similar work and all that we have been watching is the quantity of coal used per month as returned on our books. Our engines

on the mountains show a saving of coal reported between 25 and 30 per cent. The fast freight engines show from 12 to 17 per cent.; and as to the passenger test we only had the one which has been making two months run, and it is hardly fair to say what her percentage is, although it is between 9 and 10 per cent. The engines have been running along very nicely. They have given us no trouble except the little trouble we had in breaking the men in to using them. (Applause.)

Mr. J. N. LAUDER—On this question of the desirability of using the compound engine as against the plain engine, I am inclined to take rather a conservative view. I agree, to a certain extent, with what Mr. Casanave has said, that until the railroads of this country know more about the compound locomotive than they do to-day, we had better go slow and be conservative and not launch out into the unknown too rapidly. I believe, however, that out of the present experiments being made by the different locomotive builders and by some of the railroads we are going to have a more economical type of engine in a few years to handle our trains than we have ever had before. My observation and experience during the past year, both on our own road and what I know has been done on other roads, lead me strongly to that conclusion. I do not believe that for the present, or for some time in the future, we are going to get any such enormous saving in fuel as some of the figures that are presented would lead us to think, because 35 and 40 per cent., and sometimes more than that, are exceptional cases which ought not to be counted at all. The only way we can get the average and the solid performance is by a more extended use than we have had up to this time. If we cannot get more than 5 per cent., which Mr. Casanave suggests as being obtained under certain conditions, I do not think it will pay any railroad to use compound locomotives. Why? Because in the first place they must necessarily cost something more. The repairs to compound locomotives must be something more. How much the increased repairs would be, none of us at the present time know. We cannot know until three, four or five years' service with those engines in large quantities. The first cost, of course, we do know. We know pretty nearly that they will cost something more than the plain engines—not very much. Now, unless we can get an equivalent in the saving of fuel for this increased first cost and the necessarily increased cost of repairs, there is no earthly object in making the change from the simple engine to the compound. But I believe we are going to get, in certain localities at least, saving enough to warrant us in going ahead and making further experiments in the direction of compounding our locomotives. New England, the Pacific Coast, Mexico and some portions of the Northwest and other isolated parts of the country have to pay enormous sums for their fuel, and the higher the cost of the fuel, of course the greater the gain, if there is any saving in any particular type of engine.

There is one thing that I presume almost all the members of this association hold in regard to this matter, that I am happy to say I think is a myth, and that is that the compound locomotive will not do the range

of work that the simple engine will do. I believed one year ago that compound locomotives for special work must be specially designed for that work. What I mean is a high-speed engine must have a special design for high speed and would not be an economical or serviceable engine on any other kind of traffic. My experience for the past year has modified that opinion quite materially, and to-day I am prepared to say that a compound locomotive can be designed that will have as wide a range of service as the simple engine. The engine that I have had most experience with for the past year and have seen the most of and know the most of its workings, has been used on a variety of work—fast express freight, running at a speed that a few years ago would have been good passenger train schedule speed ; on heavy fast passenger trains, both express and local and on suburban trains of eight and ten cars, making eleven stops in nine miles and rather quick schedule. This engine, in each of these different kinds of service has done as good work, and in some cases better work than the plain engine that she was designed to compete with. In only one instance has she failed to do the work as well as the plain engine, and that is very quick work. This comes about from the fact that we took our standard 18 x 24 passenger locomotive, with an ordinary 5½-foot wheel, and simply compounded. My experience for the past year has led me to believe that for any passenger work the wheel should be enlarged. That, I believe, is in the same line with the experience of all other men who have had experience with a compound locomotive. I propose to go farther and build some more of these engines, simply making the change from 5½ feet diameter of wheel to 6½ and increasing the stroke from 24 inches to 26. This, I believe, will give us an engine that will do our passenger work in every respect as well as the plain engine, and I am looking confidently for a material saving of fuel—enough to warrant us in the further use of the compound locomotive. I want to be conservative in my statements made here, because they are publicly made, but I am prepared to say that I believe there is enough in the compound locomotive to warrant all our roads in spending some money to develop the engine and bring out a better type, perhaps, than exists to-day.

There is one thing, however, that I am convinced of and that is that it will take very much more careful designing—very much more able designers to design and build a compound engine than to design and build a simple engine. This perhaps comes about from the fact that the simple engine to-day is almost stereotyped. We are all building about the same thing. It may be a little different in its lines, so that its appearance is different. You would recognize a Baldwin engine or a Schenectady engine by the looks of it. But where is the difference in the material design of those engines to-day? There is very little. With the compound engine there will, undoubtedly, be a variety of types, and as some one has remarked here, it will be a question of the survival of the fittest. When these engines come to be repaired and when they have been used for several years and begin to get old, then will come the crucial test. It will be

a question then whether the engine is actually a more economical machine than the plain engine of to-day. Until that time comes it ought to be true wisdom for the railroads to be conservative but still to push ahead in a conservative way and see if the compound locomotive cannot be developed into a much better machine than we have in average service at this time.

There is one peculiarity about our compound that surprised me, and I presume that same peculiarity exists with all of them; that is the facility with which they will get a train from a state of rest up to speed, working compound. It took us a good while in experimenting with our engine, to get her so that she was right, but we succeeded finally, and that engine will get a suburban train from a state of rest up to speed fully as quick, and I think as a rule quicker than the plain standard locomotive. Every one, I presume, who makes an effort to bring out the compound locomotive will find difficulty in so arranging the draft matters. We have found difficulty there and I know others have. The quality of the exhaust is so different from that of the plain engine that it needs special appliances and arrangements to bring out the full benefit of this quality in the exhaust. The exhaust from the compound engine must be necessarily very soft and light compared with the plain engine. That is what we have compounded the engine for—to get more out of the steam before it leaves the machine. The consequence is that you do not get the draft on the fire by the action of the blast that you get with a plain engine. The result is that you may have to do a good deal of experimenting before you get the draft just in a condition that will give you the best results. We have been unable to run our compound engine with as large an exhaust pipe as we run our simple engines with. We run our simple 18 x 24 engines with a 4¾ to 5-inch exhaust pipe. We have them running with 5 inches, burning Pennsylvania coal and making plenty of steam. The compound will not run with a pipe of that size. She is running now and making steam very fairly with a 4½-inch pipe. We tried a great many experiments before we brought about the desired results in the matter of steaming. The last thing, and the one that seemed to accomplish more than anything else that we did, was to reduce the diameter of the stack and make it bell-mouthed at the bottom. The reason why it needs a bell-mouth shape at the bottom I apprehend, is that owing to the want of pressure in the escaping steam it spreads very rapidly after leaving the nozzle, and I think that with the ordinary type of smokestack a good deal of that steam strikes inside the smoke arch outside of the exhaust-pipe and thereby makes a whirl of the air and gases in the smokebox, which retards the draft. By making the bottom of the smokestack of a bell-mouth shape it enlarges it to an extent that the steam all seems to get inside of it, and it goes out giving a clean, smooth exhaust and apparently a smooth, clean suction on the fire. With this engine at present we have no trouble at all in making plenty of steam. She carries 190 pounds and will handle our steamboat train of ten to twelve cars on a grade of 44 feet to the mile for six or eight miles, at times with the door open

nearly all the way up the hill—something you can hardly expect with a plain engine.

I want once more to emphasize the fact that I believe novices cannot design to-day a correct and economically working compound locomotive. I believe that it will require very much more accurate working out of the design of valve-motion, steam distribution and pressure than we have been used to giving plain engines. But if we obtain the economy which I believe we can get, we can well afford, if we have not the talent ourselves, to employ such talent as will do the careful designing necessary to build a compound locomotive. (Applause.)

Mr. VAUCLAIN—When I am in order I would like to make some remarks in reply to Mr. Lauder.

The PRESIDENT—You are in order now, Mr. Vauclain, I believe.

Mr. VAUCLAIN—Mr. Lauder has alluded to the repairs of the engine—that the compound engine would certainly require additional repairs over and above the plain engine. I dispute that, and on this ground—that the repairs to the cylinders of the compound engine will perhaps be slightly greater than in the plain engine. In the two-cylinder type, you have the intercepting valve, etc., to look after which will require a certain amount of attention dependent on how it it is made. But there is no doubt that in that type, and in the type that I represent, additional repairs would be necessary to those parts. But have we nothing to offset these additional repairs? What is the life of the firebox of an ordinary locomotive, and what does the life of the firebox depend on? You take the steel which you put in a stationary boiler which will run at 80 to 100 pounds pressure, and it will last fifteen to twenty-five years. You cannot get as much life out of a locomotive firebox. The life of the steel depends on the number of heat units that pass through that steel; in other words, the number of gallons of water that the boiler evaporates.

A compound locomotive does not have to be forced as a plain engine has; the products of combustion are not drawn through the tubes at any such velocity as in the plain engine. There is not the same action of the sparks on the end of the tube or the rapidity of evaporation which causes the water to leave the surface of the steel exposed to the fire.

The service to which these engines can be adapted is another thing Mr. Lauder brings out. He thought that the compound engine had to be especially designed to be adapted to any particular service—for instance, suburban, fast freight, slow freight, or ordinary passenger traffic. We have twenty compound locomotives running on the South Side Rapid Transit Railroad in Chicago. They make from 200 to 245 miles daily, with a few squares between stops. They have harder surface with a 38-inch center to 42-inch wheel than any passenger locomotive on the Pennsylvania Railroad between Philadelphia and New York. They are constantly stopping and starting. As a proof that these engines are equally applicable to all sorts of service I suggest to you to examine into the action of those engines on the Chicago South Side Elevated Railroad.

In regard to the suggestion that compound locomotives should be designed in general with a larger diameter of wheel, I would say that that is not so. It is true that a compound engine will give better results with a large diameter of wheel than with a small, but the same thing is true of the simple engine. If you take a plain engine and give it a larger diameter of wheel, it will give you better results in the same service. If you take an engine with a 62-inch wheel, for passenger service, and then take the same mechanism exactly and put on larger drivers, simply increasing the cylinder power in proportion to the size of the driving-wheels, you will get a far better result and your economy will probably be as great. I think that has been clearly proved not only by engines that we have built running on the Baltimore & Ohio, on the Philadelphia & Reading, and on the New Jersey Central, but also on locomotives that the Schenectady people have built running on the New York Central.

The survival of the fittest was mentioned here to-day in the same manner in which the popularity of the engine was mentioned at the last meeting—that upon the popularity of the compound engine depended the value of the locomotive or the manner in which it was being received by the railroad companies. I do not care to say anything more about the survival of the fittest, any more than I do as to the popularity of the different types.

As to getting at results, Mr. Lauder says that before a company can use compound engines, and adopt them, they must get at results. I would ask this meeting, How are they going to get at results without using these locomotives? The Philadelphia & Reading have taken the right way of finding out about these engines. The Schenectady Locomotive Works are building a lot of engines for the far West, where they propose to get at it in the same way. Any railroad can afford to buy ten, fifteen or twenty compound locomotives and put them on the road, provided they have a large system. Any railroad that has 300 locomotives can afford to try compound locomotives.

As to the starting power, I will agree with Mr. Lauder that a compound locomotive can start equally well with the plain engine. It can start quicker than a plain engine, and why? Because it has not as much steam to get rid of to do that starting as a plain engine has. Mr. Casanave of the western lines of the Pennsylvania road is making some experiments with cylinders having large ports and long valves, and I will guarantee that he will get much better results, not only in starting, but in speed and in getting his trains to their schedule speed, and he will get better results in other directions. He will have less back-pressure at high speed, and short cut-offs and better results, I think, all through.

With respect to special arrangements for blasts, size of nozzle, etc., Mr. Lauder observed that on the compound locomotive we must have such special arrangements, different from what we have on the plain engine. The size of the stack has been changed; the size of the exhaust nozzle is less. I cannot agree with that. I give you liberty to call on any man who is using Vauclain engines in the United States, and he will tell you those

engines are running with the same blast as the simple engines. I think the Schenectady Locomotive Works can bear me out in that. With our system of having four exhausts, it is perhaps easier for us to turn our engine out with the same blast apparatus. Where we have a few cases of those engines running with a few inches less exhaust nozzle, we have fifteen or twenty examples of where those engines are running with a larger exhaust nozzle, with the same elevation of deflecting plate, the same netting, and everything the same all the way through.

Mr. Lauder said we would have to employ the best talent to design the compound locomotives. I want to know of a railroad company that is willing to turn out locomotives that does not want to employ the best talent to design them. The simple engine is as worthy of good designing as the compound. It simply requires to use the brains that they have used on simple engines to build compounds of any type. (Applause.)

Mr. LAUDER—I am sorry that Mr. Vauclain has seen fit to direct most of his argument to me, but I shall not attempt to get into any wrangle with Mr. Vauclain over this matter. I will simply try, perhaps in a feeble way, to answer some of the positions he has taken. I am not prepared to agree with him at all on the question of his repairs. I believe that the position he has taken there is entirely wrong. I do agree with him in his conclusion that the life of the firebox depends largely on the number of heat units that pass through the plates. But he neglects to mention one important feature that has a wide bearing on the life of the firebox, and that is the higher pressures we have to carry or that we do carry on a compound engine. I think that every railroad man who has the care of locomotives will agree with me that the higher the pressure is carried, the sooner the firebox will wear out. That, I think, will go without any question. Now the compound locomotive is carrying higher pressures than we have been in the habit of carrying—in round numbers, 200 pounds. Boilers must be especially designed to carry that pressure safely, and the boilers must necessarily—especially the firebox—wear out sooner.

In reference to the type of compound locomotives, I do not care at this time to get into any discussion with Mr. Vauclain, who is rather aggressive on the question of the different types of compound locomotives—the four-cylinder and two-cylinder types. I am not interested pecuniarily in either type. Some gentlemen here, perhaps, are, and would like to do a little advertising on their own account. Therefore I do not think that we should allow or encourage any acrimonious discussion as to the particular advantages of any special type of engine at this time, because I do not believe we know enough to-day about the compound engine to warrant us in doing what Mr. Vauclain says—to adopt the compound engine to any extent. He describes exactly what I advocated in my former remarks—that the large roads in this country should push ahead and make further experiments with the compound engine, because I am certain that the compound engine will make a good showing and that she has come to stay with us. But the members of this association must not expect any fancy figures in regard to

the economy of the compound. I think the compound engine will finally come down to a point where it will make a saving over the best type of plain engine of somewhere between 15 and 25 per cent. Now if you can get 15 per cent. I believe you are warranted in compounding your locomotives. Possibly in some parts of the country where fuel is high, you would be warranted in using compound engines if they showed a much smaller saving. But taking the country all over, I believe if we can get 15 per cent. economy out of the compound over the best types of plain engines, we are warranted in using the compound engine. My own individual opinion is that we can get more than that. But let us not get our expectations wrought up too high, because we may get a set-back which we do not like. We may be led into error by the statement that we can get 30, 35 or 40 per cent. saving in fuel, which I do not believe we can do.

As I said before, I have no particular controversy with Mr. Vauclain. I agree with him mainly. I did not get up here to advocate any particular type of engine as against the four-cylinder compound. But I want to say it seems to me unnecessary to build and maintain four cylinders on locomotives, with all the attending expense of repairs, when you can get equally good results out of a much simpler form of engine.

Mr. Alonza Dolbeer—There seems to have been a war among the giants in regard to compound engines. I think, with the exception of Mr. Casanave, we have heard from no one who is not a representative of some type of compound engine. I am not a representative of any type. In fact with fuel costing only $1.25 a ton, I am not an advocate of any compounding. In September or October of last year our vice-president sent for me; he wanted to know what my opinion was of the compound engine. I told him I did not know anything—that was the easiest way I could get out of it. I do not know a great deal now. I know a great deal more than I did then. The vice-president told me that he thought it was policy for us, as we were going to buy some engines, to buy some compounds and see what they could do. He believed in them thoroughly. I went to see Mr. Vail, who had a compound engine on the Western New York & Pennsylvania road. I sent a man over there who rode on that engine and got the test of the engine. The result was that we placed an order with the Baldwin people for two of the Vauclain type of compound engines. They came to us in the latter part of December. I have the record of what those engines cost. I wish to say, Mr. President, that here is a sample of the grades which are on the division where these engines were used. (Showing a blue print). When these engines were received, we received in connection with them two engines of the same type—one compound, the other simple. We carry 175 pounds pressure upon the compound engine, while we carry only 140 on the simple engine. I believe if I could get 175 pounds on that simple engine I would get better results—that the comparison would show far better results.

Four of these engines came to us together. I concluded that now is the time to immortalize myself and to know all about them. The result was I took four of the best engineers we had on the road. I put two of

them in charge of the compound and two in charge of the simple engine. We started out in the month of November. We ran only ten days and I found my compound engine showed a saving of 16 per cent. in fuel as compared with the two simple engines. This, bear in mind, was not on the tonnage basis; it was based on the car mileage basis. The tonnage was not included. In the month of December it dropped down to 12 per cent.; in the month of January we got 32 per cent. saving. I thought that that settled it. The weather got bad about that time. Probably I did not give it much attention. Probably there was a good deal of trouble among the men; they do not like compound engines. I do not need to tell you who have compound engines that the engineers do not like them. But the result was that I dropped down in the month of February to 6 per cent. Well, even then there was bad weather. In the month of April I made an arrangement for getting a tonnage test. About the 15th of April we got our record for our March tests. I discovered, somewhat to my surprise, that the simple engines had made a saving of 7 per cent. over the compound engines. (Laughter.) Well, I began to look around to see what the matter was. I observed the man I had selected to run the compound engine had been promoted to road foreman, and he did not give it very much attention. He was the man that had been making the record. I discovered that the other man who had been making the records had been promoted to a passenger train. I do not know who was on the engine; it was pretty hard to tell. I sent for the road foreman and I said "George, do you see that record?" "Yes." I said "Do you see that one over there that shows 32 per cent. saving? You ran that engine at that time, why is it you cannot get that result now?" He said he did not know. Finally we got over this thing and the weather got better and we did improve. The result was that in the month of April, including the first fourteen days, I got fifteen per cent. of economy in fuel from the two engines. In the month of May—a portion of the month of May, I think up to the 20th—I again made a saving of 12 per cent. Now that is what the report has been. Of course I believe that there are many benefits connected with the compound—I will say frankly the principal benefit is the saving of fuel. I do not believe that a road whose fuel does not cost over $1.25 a ton wants to bother with compound engines. In placing an order for eight engines a few days ago, the question was asked whether we wanted any more compound engines; I frankly said no; we had got two. If you will notice (referring to blue print) there is a long pull from here up and then there is a drop over. Now we have one place on our road where there is seventeen miles of a steady pull and a maximum grade of seventy-five feet per mile. I propose to put the next engine we receive on that ground and I do believe we may get some results.

I find complaints; the question of repairs comes in. I do not mean to quarrel with Mr. Vauclain, but I will say frankly right here, you try them awhile and you will find you have repairs to make on them. All these tests are made with twenty or twenty-five pounds more pressure on the compound

engine than on the simple engine. I do not believe it is fair to make the test without putting an equal amount of steam on the simple engine. There is not a man here who does not know that when an engine gets a hard pull the boys screw down the safety-valve a little bit. What do they do it for? To get that load over. How many here have not had examples of engines that have done wonderful service and finally it has dawned upon them that the boys have got about fifteen pounds more pressure on the boiler than you were carrying before. Here is a cut of the tires of two engines I have been speaking of, Engine 56 with a mileage of 17,124 miles, and here is the simple engine, Engine 28, with a mileage of 19,884 miles. That is the wear of the tire. The wear of that I am inclined to think is nearly one-eighth of an inch more. Why? Because of the slip; that is all. Mr. Dolbeer exhibited diagrams of the tires.)

Now, the compound engines have some good points. One day, I said to one of our engineers, the first one that I spoke of as running these engines, "George, how are you getting along with your engine?" He said: "I don't think much of it. I was down on the grade the other day, coming between Ashford and Palmersville, where we have a hard pull on that hill. It was all I could drag; and finally the train broke in two. I made up my mind that I would have to go to the foot of the hill. I backed down the compound, and I pulled that train over the hill and started it over the grade." Speaking only of the Vauclain engine—I do not know anything about the other—I believe there are emergencies where, if you only have a little more power, you would get yourself out of a hole, and I believe the compound engine gives us a chance for that. I have shown you the grades that we have. You will see that that is not a place to use compound engines and get results. However, looking it all over, with coal $1.25 a ton, I will say that I do not want any more compounds at present.

The convention then adjourned until the following day.

SECOND DAY.

The convention was called to order at 9 A. M.

The PRESIDENT—The order of business will be the continuation of the discussion of the report on compound locomotives. I would like to hear from Mr. Soule if he is in the room. But before opening the discussion the secretary will read the report of the Auditing Committee.

REPORT OF THE AUDITING COMMITTEE.

Secretary SINCLAIR read the following report:

Your committee have examined the accounts of the secretary and treasurer of this association, and find that the same agree with the reports presented by these officers.

JAMES M. BOON,
H. N. SPRAGUE,
W. H. LEWIS.

DISCUSSION ON COMPOUND ENGINES CONTINUED.

The PRESIDENT—If Mr. Soule is not in the room, I would call on Mr. A. E. Mitchell, of the New York, Lake Erie and Western.

Mr. MITCHELL—On the 1st of last January we bought from the Baldwin Locomotive Works five compound decapods, weighing about 205,000 lbs. apiece, with cylinders equal to 24 x 28 inches. These engines were bought to place in service on the Delaware division, where we require three engines to get one train up the hill, the distance being 8¼ miles. We figured that the tractive power of one of these engines was equal to that of two consolidation engines. One of these decapods, therefore, would take the place of two consolidation engines on the hill. Since they have been in service they have fulfilled the duty expected of them in a very efficient manner, and we are burning on these engines culm and buckwheat coal, often using pea and buckwheat. But it is a cheaper grade of coal than what we are using on the consolidation engines, which is lump anthracite. One fireman can easily fire that engine, without any difficulty whatever, maintaining 180 pounds of steam. The engines, as I said before, have been in efficient ser-

vice ever since they were put to work January 1st, and we have no cause of complaint of the service we are getting from them. The engines steam freely, and are burning, as I say, a very cheap quality of coal. As for repairs, we have not had compounds on our line long enough to decide what the repairs would amount to, but from what we have seen so far I do not think the repairs are going to be very extensive, although we cannot tell until we have had them in service at least a year. There is one thing, though, on compound engines that was not brought up yesterday, which I think is going to be of advantage to railroad companies, and that is the mild exhaust preventing throwing fire. We find that with the compounds we have in service we are not throwing any fire from the stack, and therefore we are not liable to settle for fire claims for damage to property along the line. That, I think, will be one of the main points in compounding, in addition to the saving of what fuel we will save.

I was very much pleased with the report yesterday from Mr. Gibbs relative to tests on the Chicago, Milwaukee & St. Paul, as I made a great many myself and I know the difficulties they had to contend with. But I think they made as complete a report as it is possible to make, entering into all details that it is possible to enter into and eliminating all errors that you have got to look out for on tests of that kind.

The PRESIDENT—I see Mr. James Macbeth, of the Adirondack & St. Lawrence, who has a number of compound engines in use. We would like to hear from him.

Mr. MACBETH—There is only one clause of the report that I would like to refer to. It is not clear to me, and with your permission I will read it. I have not found the fact to be as stated here—that is, on the two-cylinder compound:

"It will be seen that for the steam distribution used for 100 revolutions, and with the weights of reciprocating parts as built, the simple engine gives a much more uniform pull than the others. Also, that if the compounds were reduced to the same average pressure, the variation would be nearly the same in both. At 150 revolutions, the four-cylinder compound gives the smoothest line and the simple engine is somewhat better than the two-cylinder compound. At 240 revolutions the four-cylinder compound shows the least variation and the single engine the most. These facts are further illustrated by the following table, showing the proportional variation of each engine above and below the mean pressure. It is clear from this, that in this case at least, the rotative effort or returning movement of the two-cylinder compound is not more uniform than that of other locomotives. There is also evidently a definite combination of steam pressure cut-off, weight of reciprocating parts and speed for any locomotive with which it will develop its most uniform pull."

My reason for taking this paragraph up in the report is this—that when I stood and looked at the two-cylinder compound it became a question in my mind whether the engine was going to ride properly or be properly counterbalanced—whether we were going to figure the same pressure on

the one side on the simple cylinder as on the compound. Figures have not been a large part of my experience, which has been practical experience all the way through, so I thought I would find out for myself and I put Mr. Pitkin to a great deal of trouble in running an engine on the Schenectady branch. I had to run her on freight for two or three days. She had a 51-inch wheel—consolidation engine. I made him leave the drawbar between the engine and tender three-eighths of an inch loose. What I wanted to get at was, the side oscillation in those engines. I was satisfied that if his heavy engines had as much side oscillation no one could keep them together. I rode on this engine two or three times. We ran her down hill 30 or 40 miles an hour with that 51-inch wheel; then we ran her 30 or 40 miles an hour without steam. That was my first experience, and I must say it was very satisfactory. She was as straight a riding engine as I ever rode on.

I then went to work and spent three days before I would commit myself to Mr. Pitkin or to our president. They wanted to know my opinion, and I told them I did not have any opinion. So I went to work and made it my business to use up three days in going to Detroit and riding on a ten-wheeler which is a duplicate of the engine down here at the shop, only about 8,000 pounds lighter than the one here. I rode on her on the limited from Detroit to St. Thomas, and I found the very same result that I found on this engine with the 51-inch wheel. She had a 6-foot wheel. She rode as perfectly as any engine I ever rode on. That was my reason for bringing up this point, that I could not understand how they found these results, that a two-cylinder compound did not ride as steadily as a simple engine or four-cylinder compound—something that I had not found. We have got ten on the line—eight under service, the other two here at the depot. We have not found one that does not ride just as straight as any engine ever rode.

Another matter came up yesterday in reference to the exhaust tips. We have found a radical difference all the way through from what was stated yesterday. We are using a 5-inch single exhaust tip, and have had no trouble from steam. Some of our service is very hard—125 feet to the mile—and we never have had a particle of trouble for steam, and we have never had any trouble with coal.

Mr. Mitchell spoke about fires, and I feel safe to say, where we are running through a dense wilderness all the way, that I think our chances of fire are 30 to 40 per cent. less with this engine. This is one of the reasons, I believe, why my people wanted them compounded.

I have just finished a test on the Central Vermont Railroad with one of our compound engines and a simple Baldwin engine that showed a saving of from 30 to 35 per cent. of coal, and the evaporation of water was 8¼ against 5½. We made that experiment on a piece of road 30 miles long, 10 feet up hill, and a grade of 37 feet to the mile; the rest was level.

The President called on Mr. Butler to speak.

Mr. L. M. Butler—We are running a compound engine of the two-cylinder type, built for our road by the Rhode Island Locomotive Works.

I have not had it long enough yet to give you anything of value. We have hardly run it two months, so I think the less I say the better.

Mr. F. W. DEAN—In regard to the matter of side oscillation of the two-cylinder type of compound, of course I have had some opportunities to observe them, and on the Old Colony compound, when that engine first came out, she had considerable side oscillation. That almost absolutely disappeared upon taking off the cylinder-heads of the high-pressure cylinder and turning off a quarter of an inch and getting more clearance—that is giving more volume for the compression. It is obvious that in that case the disturbing influence would be less. It was noticed that the side oscillation increased as the engine got loose in her housings, but now it is very difficult indeed to see any such oscillation, and if the cylinder head was thick enough there would be no evidence whatever. As I say, you have to look pretty sharply to discover it now. I made the cylinder heads thicker than was necessary for strength, anticipating that I might have the difficulty of excessive compression, and that difficulty can be made entirely to disappear by giving sufficient clearance—I do not mean valve clearance, but I mean clearance in volume between the piston and the cylinder heads, or going up further, to the valve face. The Old Colony engine has in the high-pressure cylinder 11½ per cent. of clearance. That is, the per cent. is reckoned in parts of the piston—the volume swept through by the high-pressure system. I think it would be desirable for it to have about 15 per cent. I think, then, that that is all that remains to be done to entirely do away with the side oscillation that occurs, and to make the two-cylinder compound just as smooth a running engine as the simple engine. On the low-pressure cylinder, if I remember rightly it is about 5¾ per cent. In another design I would increase that very much. I do not know exactly how much, but I could tell very readily from the indicator diagram that I have.

I want to say something about tests that we have recently carried out on express passenger work in competition with a simple engine of the Old Colony standard, and before going into any details of that I want to give my reasons for thinking that in competing with the Old Colony standard engine I had a more difficult engine to work than the majority of simple engines. The indicator diagrams from the Old Colony simple engine show, to the best of my judgment, that there is nothing to find fault with, but that they take as good indicator diagrams as any locomotive that I have ever seen. So much for that.

Now Mr. Lauder makes his cylinders with an air space in front of the steam passages and behind, and also an air space between the steam and exhaust passages. Of course, we all know that that is not common practice; that most cylinders have not those air spaces. Moreover, he also closes up the bottom of the cylinder with a plate of iron and a plate of asbestos on top of that, so there is no opportunity for the atmosphere to circulate about the steam passages. There is no air space on the outside of the passage, that is on the side of the cylinder saddle or the cylinder. In other words the steam passages have air spaces on three sides. It is ob-

vious therefore that the Old Colony standard engine must condense less steam in that way than most simple engines. In fact, I do not know of any simple engines that are so well protected as they are, and that is why I think the Old Colony engines are unusually difficult to beat.

In making our comparisons in the first place, when we made our tests on fast freight which averages a speed of 25 miles per hour and which reached a maximum of 45 to 47, we took an engine which was built exactly at the same time as compound engine No. 235, an account of which appeared recently in some of the papers. The erection of the engine was begun on the same day as the compound and they were finished at about the same time. Both engines had been running about a month before they were tested and we took all due precaution, we thought, to make the comparison proper. We had a piece of misfortune in this respect. We laid out Pocahontas coal enough to test the simple engine. We tested two of them, but I will speak only of 235 because that was the only new engine we tested on that train. We made one or two trips with the compound with that coal. The next day we went to get our coal and found that it had been covered up with Cumberland coal. The boss of the coal shed, I suppose, had no idea of the importance of having all the coal right, but the evaporation fell off 12 or 15 per cent. At all events, the coal was confessedly inferior, and I think all who are familiar with those coals know that there is more heat in Pocahontas coal than there is in Cumberland; at any rate the saving on that train was about 31 per cent.. I think if we had had Pocahontas coal throughout, the saving would have been 38 per cent. The method of making tests was this—the train went from Boston to Fall River, which was about 50 miles, and we began to built a wood fire in Boston and went down to Fall River in the afternoon, banked the fire all night and came back in the morning with 25 long cars. In returning to Boston we let the fire run down below and then dropped it. We made no account of the wood, because I assumed that the wood did not cost much. It was of no particular value to the Old Colony Railroad, and moreover the amount of coal we dropped out of the firebox might be considered fairly equivalent to that. The saving of the coal was based on the actual amount of coal used. The water records were interfered with a good deal by blowing off. Per car-mile the water saving figured up about 13 per cent. The simple engine blew out rather more than the compound did. The compound carried about 175 pounds of steam and the simple one, I believe, a little upwards of 160. I suppose when the compound blew off she blew off more steam to the minute than the other did. I said nothing to the engineer about the proper way to run the engine. I let him drop into his own method and told the fireman to have the engine blow off as little as possible.

After the compound had been running six months in continuous work we began our tests, which we called our efficiency tests, on the express passenger work, two years ago last November. I tested, on the ten o'clock Shore Line train, an Old Colony standard engine, No. 148, which at that time had

been running about a month and had had her valves nicely adjusted to the indicator and was in splendid order ; and a year ago last October we tested that same engine on the Fall River Line boat train after she had been in the shop and it came out in very good shape ; in fact I don't know but that she is just as good as new. The valves and pistons were tight and she steamed well and worked admirably. We also tested Engine 229, which was the regular Fall River Line boat train engine at that time. She had been running, I think, some six months. The compound we tested very recently on both those trains. We have not worked up all the records on the ten o'clock train, but it is obvious that the saving is fully 30 per cent., and those tests were made in the same way that the express freight tests were made. That is, we began our fire in Boston, went to Providence and banked the fire and then returned and let the fire run down as low as we could, precisely as in the simple engines. Then we took the compound on the Fall River Line boat train which consists of anywhere from 9 to 12 cars and occasionally 13. We did not have 13 on any of the tests, but we did have 12, and then again for car mileage the tests showed a saving of just about 30 per cent.

Those tests are rather interesting. They are interesting in this way—they seem to show that the engine is extremely economical in any sort of service. It does not make any difference whether it is hard pulling or light pulling or fast. On these passenger tests the saving in water was about 21 and 22 per cent. In due time, of course, I can work up those tests elaborately and all will be known about that. On this Fall River boat test, however, the results that we now have are the final ones, because they are based on car mileage, I propose to base the other tests on coal and water per hour per horse power.

The other compound engine that I have been connected with is on the Lehigh Valley Railroad. That has cylinders 20 to 30 x 24 and carries 180 pounds of steam. That engine has not shown the economy that the Old Colony has. It was put to a service which I did not expect. It never occurred to me that that engine was to push coal trains up a 96-foot grade at 12 miles an hour. I fancied she was going to be used in a sort of general run in a more level situation. The cylinder ratio is 2¼ to 1. I wish it were 2 to 1. Then, although she might have the same total expansion, it would be divided between the two cylinders. In pushing 30 coal cars up a hill they cut off at 17 inches, and, of course, that is altogether too late. She ought to be compelled to do the work with a cut-off not much later than 12 inches, and the only way to accomplish any thing of that sort when you are limited as to the size of your low-pressure cylinder, which you must do—you cannot stick out beyond your telegraph poles—is to make your high-pressure cylinder larger. You will then get the total expansion that you expect to get anyway well divided between the two cylinders and that gives the minimum condensation with the best results. The Old Colony engine shows a better performance in consequence of having a larger high-pressure cylinder, and she does most of her work with a 12-inch cut-off. She pulls

those trains up a grade 44 feet to the mile, I think. But she does that on schedule time, in 12 inches, with 180 to 185 pounds of steam. Of course, that is a very early cut-off, and of course, it must give very economical results. The engine is certainly highly economical, and while there may be an opportunity for error in water observation there is no opportunity for error in coal consumption.

To return to the Lehigh Valley engine. That engine was tested in competition with a simple locomotive, built, I believe, by the Baldwin Locomotive Works. The simple locomotive has 180 feet of heating surface more than the compound, and that is about 9 per cent. more of heating surface than the compound has. Cutting off at seven inches the engine shows a saving of 16.4 per cent. on the coal and 13 per cent. on water. More recently the engine has been taken down between Easton and Packerton and has made ten round trips—470 miles, I believe, is the aggregate. In making those ten round trips the simple engine was 44.88, and the compound was 42.88 hours. That is to say, the compound did her work in 2.08 hours less time, and the weight of the train was 8,380 tons for the simple and 8,550 for the compound. In other words, the compound not only went faster, but she pulled 170 tons more. The saving was 19.61 per cent. in coal and 23.99 in water. That test I took no part in.

Now, I have been interested in a little computation on the subject of train resistances. That is, assuming that the train resistances were proportionate to the square of the velocity, I computed the amount of coal that the simple engine would burn if she had run as fast as the other ; then, again, how much she would have burned if she pulled as large a train as the compound, and the saving comes out 28 and some tenths per cent. Then on top of that I computed the amount of coal which the compound would have burned if she had evaporated as much water per pound of coal as the simple engine did. The simple engine evaporated 6.6 per pound of coal and the compound 6¼. The saving would be 32.4, I believe. Of course everybody knows that such computations as that are not strictly correct, but they must be somewhere near it. For instance, if you get 32 per cent. you might safely count on 28—something of that sort.

I want to say a few words in regard to the principles of designing compound or any other engines, in a general way. In designing a locomotive it is desirable to have the cylinder surface as small as possible. The condensation in cylinders is proportionate, roughly, to the amount of cylinder surface, and by using the smallest number of cylinders you can, you necessarily have the smallest amount of surface. Therefore, speaking in a general way, the engine which has the least amount of cylinder surface will have the least cylinder condensation, and will be the most economical engine. Now, it is perfectly easy in designing a compound engine to so design it that the expansion through the two cylinders will be continuous, and it can be shown mathematically that if the cut-off in the low pressure cylinder is at that point which is determined by the cylinder ratio, the expansion will be continuous through the tube ; that is to say, the low press-

ure cylinder will begin its expansion at the pressure at which the high pressure leaves off, and therefore, as many people have supposed, and I presume still do suppose, the objection to the two-cylinder type of engine—that you cannot expand your steam continuously—disappears. It is well known that you can, and it will be so when running at slow speed, so that there is not any drop due to friction in the capacity of the two cylinders. In the two-cylinder engine that can be accomplished exactly by having two reverse levers, one for the high-pressure cylinder and one for the low, and in that case the quadrant for the low-pressure would have a mid-gear notch and a full-gear notch, and one notch in between, at which it would always be worked, and in that way the most desirable results would be obtained. Of course most people will think that it would hardly pay, and I do not think it would myself, to have two reverse levers to accomplish that result.

Now to come back to the matter of cylinder ratio again; if any compound engine has a high-pressure cylinder so small that you are obliged to run three-quarters to full stroke in order to get sufficient steam through the engine to make it do the work, the engine is no longer a compound engine; that is to say, the high-pressure cylinder becomes a sort of steam feeder. It measures off, every time, so much steam to be expanded in the low-pressure cylinder. Such an engine as that cannot give the best results, and the only way, as I said before, to overcome that trouble, is to make the high-pressure cylinder sufficiently large to cut off early. I do not think that for a given amount of work a four-cylinder engine can be designed to do the same amount of work as the two-cylinder engine without having about 50 per cent. more cylinder surface; and, of course, great condensation must follow, and I think that is the great point about the two-cylinder engine, let alone the simplicity of the matter. All mechanical minds certainly admire simplicity just as much as nature does not admire a vacuum.

Mr. William Forsyth—In further discussion of this subject, I think we ought to take up the report of the committee. It is probably the best piece of work on a locomotive test that has ever been presented to this association, and the committee deserve a great deal of credit for their accurate and complete work. In looking over the first part of it I find that they do not ask us to accept their figures as conclusive; they think the subject ought to be continued for future trials; and I am very glad that this committee has been continued for this work. The report covers, of course, only one small phase of the subject, that is, the comparison of the Vauclain engine with a simple engine of similar type, and that is still further narrowed down to a test of this engine in freight service, so that there is still large scope on the subject of compound engines in the matter of testing other types and in testing them in passenger service.

Next in the report is the statement of the number of variables entering into the road test as being enormous. Now that is so, and for that reason I think that the first thing to do, when going into a locomotive test, is to

narrow down those variables as much as possible. I would therefore criticise, to some extent, the manner in which the committee have gone at this work in attempting to apply a long, scientific, accurate test to a freight train in regular service, and to attempt to get in that way average results, and the results obtained by a test of that kind are shown in the report to be extremely variable, and, as the committee themselves admit, it is very difficult to draw any conclusions from it.

If you will refer to some of the tables here you will see what a variation there is. In Table III we have the coal per ton-mile on the same engine varying from .073 to .15, one being nearly double the amount of the other. Then if we put it on the basis of comparison of the coal per horse power per hour, we have 5 pounds in one case and 3.1 pounds in another case, showing that an attempt to get at an accurate test of the locomotive with a train in regular service is not very satisfactory. And in further considering the subject I hope that the committee in making their more accurate measurements will confine themselves to a constant train on a regular schedule as near as possible, and then in order to get fuel economy, as on the basis of what they started out—that is on average service—to simply measure the coal from trains in regular service extending over a long period.

The superior economy given in the final conclusions of the committee to this compound of Mr. Vauclain's, as compared with the simple engine of a similar type, is stated as 6.1 per cent. one way and 9 per cent. another, and a final figure of 7.6 per cent. Then there is a further conclusion at the end of the report, showing 6.9 and 14.1. Taking even these highest figures, say, 15 per cent., I should say that is a very low economy to be obtained from a compound engine in freight service, and that we ought to obtain a much higher economy, and I think it has been found to be a common experience that the economy of a compound passenger engine is very much lower than a freight. So that we should expect from a compound engine of this type, in passenger service, not more than 7 or 8 per cent. During the past month, we have been testing a Baldwin ten-wheel compound engine, which was built for experimental purposes, and we just got through with our test of that engine before I left, and I have the figures relating to that test; but we are testing our own compound engine and our own simple engine with it now, so that I have not the comparative figures, but I will present the figures relating to the passenger test as a matter of interest in supplementing this report, of tests of a similar type of compound in freight service. The Baldwin ten-wheel engine was tested on our Denver express, having extra cars, making it equivalent to a twelve-car train weighing 486 tons, and the average speed was 42 miles an hour. You will see that that is very heavy passenger service. The length of the run was 165 miles. The figures obtained from a number of tests show an average of 5.64 tons of train, including the weight of the engine, per pound of coal and, put on a comparative basis, eliminating the difference in coal, the figures are 6.64 tons of train per pound of combustible:

TEST OF BALDWIN COMPOUND No. 82,

BETWEEN CHICAGO AND GALESBURGH—CHICAGO, BURLINGTON & QUINCY R. R.

AURORA, June, 1892.

DATE, 1892.	Train No.	No. of Cars.	Mean running weight of Engine and Tank in lbs.	Weight of Cars, in lbs.	Weight of Train, in tons, including Engine.	Water used, lbs.	Coal used, lbs.	Actual lbs. of water per lb. coal.	Lbs of water from 212° per lb. coal.	Lbs. of combustible.	Actual lbs. of water per lb. combustible.	Lbs. of water from 212° per lb. combustible.	Tons of Train per mile per lb of coal.	Tons of Train per mile per lb. of combustible.	Average speed of Train, excluding stops, miles per hour.	Remarks.
June 3	1	11	197,100	726,890	462.0	72,357	14,000	5.17	5.96	11,861	6.10	7.03	5.36	6.33	42.7	......
" 4	6	13	197,100	811,260	504.2	62,400	14,100	4.42	5.08	12,275	5.08	5.84	5.81	6.67	43.1	......
" 6	1	12	197,100	772,920	485.0	....	14,872	.....	......	12,472	......	......	5.29	6.32	42.7	Meter broke.
" 7	6	12	197,100	771,350	484.2	72,077	12,650	5.69	6.53	11,076	6.50	7.47	6.22	7.10	43.0	......
" 8	1	12	197,100	819,330	508.2	72,451	15,500	4.67	5.36	12,362	5.86	6.73	5.33	6.68	40.5	......
" 9	6	12	197,100	758,700	477.9	67,837	13,333	5.08	5.83	11,477	5.91	6.78	5.82	6.76	42.0	......
Average...			197,100	776,740	486.9	69,420	14,070	5.00	5.75	11,920	5.89	6.77	5.64	6.64	42.3	

NOTE.—The mean running weight of the engine and tank was assumed to be 218,100 lbs. — ½ (7¼ tons coal + 28,000 lbs. of water).

If the secretary will accept it, I may supplement that by subsequen figures, which we obtained from our own engine for comparison. As the result of more than a year's experience with the two-cylinder compound engine, we have found from the performance sheets an economy in freight service of 30 per cent. over our simple engines of the same type. We are just now testing these engines in passenger service. As the result of our experience with this engine, I would go a little further than Mr. Casanave went in his remarks yesterday, and would say that I would not hesitate at all, if I were to buy locomotives for myself with my own money, to buy compound locomotives for freight service. I believe that the principle is correct, from an engineering point of view, and I have no doubt that it will in time become the prevailing practice. (Applause.)

Mr. J. N. Barr—There is one point in Mr. Forsyth's remarks that I want to object to, and that is where he says that in making tests we want to narrow down the variables. Now it is the variables which make it questionable whether a compound engine is of actual service on a railroad. We know that a compound engine is a good thing where the work is steady and uniform. We know that in marine engineering, we know that in stationary engineering we can design a compound engine that is more economical than a simple engine—somewhat more economical. I have been considerably interested in this matter and I have gone over the celebrated experiments of Hirn in Germany. I failed to find, however, in those experiments that he feels satisfied that you can by compounding obtain an economy of 10 per cent. over the best construction of simple engine; that is where you can compound your engines, adapt them to the work that is to be performed and keep everything uniform. Now it may be that the compound engine is better able to meet the variable requirements of railroad service as a locomotive than the simple engine. It may be that it is decidedly the other way. We do not know. But if the committee in making their tests will start with a uniform load and a level grade and have the wind the same all the time, I do not believe they will give us any information next time that will be worth the paper it is written on. I think that the report of the committee, so far, demonstrates that. The very conflict that is presented there arises from the fact of the variables that are introduced, and every train that we run over the road every day, introduces those variables. Now we have been doing a little too much in the way of eliminating variables in our general tests of other railroad work. We have eliminated variables and then made conclusions from the results that are not sustained in practice. We can take boiler steel and get a good elongation and put it in a box and it cracks; we have not taken into consideration all the variables; and I notice in specifications and so on for materials there is a great deal of that work done, and, in my opinion, it ought to be carefully watched, making conclusions from the tests from which the variables have been carefully eliminated. If we were buying steel to use it for getting long elongation then that test would be a very good thing. If we were buying locomotives to take 800 tons of a train-load over a level road at a certain rate, no meet-

ing points to run fast for, no side track to lie on, then that test would be perfectly satisfactory. But we are not doing that, and that is one point where the difficulty of making any conclusions from these tests comes in.

I like very much Mr. Paxson's idea: take a division, put half the engines compound and half simple, instruct your engineers as carefully as possible, try to remove any prejudices from their minds which they may have, and then let them go and let it tell the story. That is what you have got to do with a compound engine after a while, anyhow. It has got to go in there and make its own record, and it has got to go in there without being covered over with water meters and indicators and speed recorders and dynamometer cards and so on. (Applause.) I think, gentlemen, that that is a very important point. I have made a great many tests of different materials—for instance lubricating oils. Every time that I made a test of lubricating oil and found that it would beat anything that we had completely, when it was put out on a division we did not get good results. I am inclined to think it is the same thing with the compound engine. I do not want to say anything against the compound. I do not know enough. I am in the position of some other gentlemen in this matter; I am a good deal of an agnostic, and I do not want to get my foot in it so deep that I cannot pull it out. Now if we can make an improvement, it is our business certainly to take hold of it. If we are sure that we can make 10 per cent. saving in fuel economy, I believe that we certainly should use the compound—just put it into use as fast as we can. I know that in our section of the country, if we can make 10 per cent. economy in fuel, it is going to pay twice over and three times over any increase in expense for repairs of locomotives. If I were sure of that, I would not hesitate one moment in saying that we are going to put the compounding principle on every engine that we put on the road hereafter. But unfortunately I am not sure. The data that we have got I cannot construe into teaching that thing. Now the committee has had a great many of these points impressed upon them during the tests of the past year. I have been pretty close to this committee and I have seen pretty closely what they have been doing, and it is for that reason that I moved the other day that the committee be continued. They are beginning now to see pretty clearly the difficulties that lie in the way of coming to definite conclusions. They are beginning to see pretty clearly what information they want to ask of the other railroad men in the country, and I say this, that the committee will need the co-operation and the close observation of all other members of this association who have got compound engines, with a close description of the circumstances under which they have been used and the results obtained. (Applause.)

Mr. M. N. Forney—I have a distinct recollection of getting into very warm water at Cape May a year ago in regard to some remarks that I made about an indicator. I have speculated a good deal about my position since that time and the causes of the temperature of the water, and the solution of the difficulty was only presented since I have been present at this meeting, and if this audience would excuse me for telling a little story at my

own expense, perhaps they will understand why that water was raised up to such a high degree. A gentleman was coming down in the elevator in the building in New York in which I have my office and overheard the conversation of some one else, who apparently had just left my office, who made the remark that "that man Forney was a damn fool and always said just what he thought." (Laughter.) I am very much afraid that in this discussion of compound engines I may say just what I think, and I think you may agree with the gentleman—that that is the true character of the person who is addressing you. (Laughter.)

In regard to this compound engine question I am, as Mr. Barr says, an agnostic. I feel that the advantages and superiority of the compound engine have not yet been fully proved, but I think that in taking up this subject we should see clearly what the real question before us is. Now I conceive it to be this: Supposing a railroad company wishes to have a certain number of locomotives, those locomotives to weigh, we will say, 100,000 pounds. Suppose under that condition of things that the general manager of the railroad should go to a builder of compound engines and say to him: "We want you to build engines weighing 100,000 pounds for such and such traffic," and suppose that same general manager should go to some other builder of engines and say: "We want you to build us some simple engines weighing 100,000 pounds for such and such traffic"; and that he were to tell each builder that he would not be obliged to conform to any conditions except those he saw proper; what he had to do was to put 100,000 pounds of iron and steel into the form of a locomotive to give the best service. Whatever advantage the compound system gave, the builder of compound engines could avail himself of; whatever advantage the simple system gave, the builder of simple engines could avail himself of. Under those conditions we have two locomotives in which we may imagine we have the highest degree of efficiency of the two systems.

What do we find under those conditions? In the first place, it is generally acknowledged that compounding increases the weight of the locomotive considerably. Now to the extent to which we increase the weight of the engine it is a disadvantage. The simple engineman, under those circumstances, might take that extra weight and put it into the boiler and get a larger boiler on his simple engine, so as to get greater efficiency from that larger boiler. A trial made with engines of that character would, I think, reveal what are the relative advantages of the two systems. If the system of simple engines has an advantage in weighing less, why surely you have a right to avail yourself of that. In the comparisons and tests and discussions that have been made, it seems to me that in nearly every instance the compound engines have asked for odds in their favor. They have asked to make the engines heavier. They say, "We only put it on the truck." Well, gentlemen, if you will allow me to put the weight of the simple engine on the truck I will get an advantage.

At this meeting we have been presented with some additional evidence on the subject. It is contained in the report of the committee appointed

last year to undertake this test, and it is presumed, and I believe true, that they went at it in an entirely disinterested way, and they have presented us with a mass of figures showing some deductions they have drawn. I have taken the trouble to make a few figures on that on my own responsibility. I have taken, for example, the two curves of tests which have been made with the simple engine with a pressure of 180 pounds, using Braceville coal, and have taken the consumption of fuel per ton per mile, and I find it is .128 per pound of coal. I have taken the compound engine and I have found that it burns .118, making an economy of 8½ per cent. in that group of tests. Eight and one-half per cent. is not a large amount. I would venture to say that any gentleman here present might make that difference in two engines by simply painting the smoke-stack of one sky blue. I think, if you are careful in making the tests of any locomotive it will make a difference of 8½ per cent. If we take the tests made with Braceville coal at 200 pounds pressure—there were no group tests made with 200 pounds pressure with that coal—they burn .104 per ton per mile, showing an economy of 19¼. Now that is asking odds of the simple engine. It is no indication of the superiority of the system.

Now we will go down to the Pittsburgh coal. The simple engine there used 200 pounds pressure and burned .088 of a pound. The compound engine burned .078, showing an economy of 11.5. Now, Mr. Chairman, the question is whether that amount of percentage is sufficient to justify us in using the new system. I made some very rough figures in regard to that, which, perhaps, can be remembered without being printed in any form. I think most of the gentlemen will agree with me that an ordinary engine burns about $2,500 worth of coal a year. Fifteen per cent. of saving would amount to $375. To get that saving you have a locomotive that costs about $750 more than a simple engine. To be on the safe side you should allow ten per cent on that additional investment. You therefore have a saving of $300 in the course of a year where the coal does not exceed $1.50 a ton. I think you will all agree with me that it is a very easy matter to use up $300 on extra repairs of a locomotive engine, and therefore I have taken the saving at fifteen per cent., which is considerably higher than the average saving shown by your committee.

There is still another question which comes in here. One of the most important things in locomotive engineering, or in building locomotives, is to get locomotives that will do the work. It is not a question of getting locomotives that will make a good indicator diagram. It is not a question of getting locomotives which will show good results from very careful tests when all these variables are brought into consideration. The business of a locomotive is not to burn variables—it is to burn coal. (Applause.) The important and overwhelming question, the one which your general managers, your directors, everybody, asks you is, How long can you keep your engines in service? The most important question is the number of miles you can run in the course of a year and the number of cars you can haul. The question of hauling cars is of infinitely more importance than the saving of

coal. Now, is it probable that we can get an amount of service out of the compound engine which is equal to that of the simple engine? If the compound engine is not able to give as many miles service in the course of a year as the simple engine, it will condemn the system.

Having spoken on that side of the question, I should like to say something on the other side.

Of course we are all interested in having the most economical engine. If on careful tests we find that the compound engine will make a saving anything like that claimed by its advocates, of course we will all have to use the compound engine. But I think it becomes this association to go very slowly in the matter, to be very careful what they do, before they commit their companies to the use of a system which has not had sufficient time to be thoroughly investigated. It strikes me, therefore, that a good plan would be to appoint two committees on this subject, one consisting of the advocates of the compound system, to get up a compound engine of the very best character they can find, and the other consisting of gentlemen like Mr. Barr, who are agnostics on the subject, and let them get up the very best simple engine that can be found, and then have a competition of these two engines and let the advocates of the two systems have charge of those tests. I think in that way we would be more likely to get at the real facts of the case than we are in the tests which have been made. It is unfair to try a man for his life without giving him counsel. It is unfair to try the simple engine before the public without giving it counsel. Therefore I think there should be a committee to stand up for the simple engine. It may be that the simple engine can be improved still more than it is.

You will observe that in these tests that have been made, in the burning of Pittsburgh coal the compound engine shows considerably less saving than in the burning of Braceville coal. Now it certainly would be a disadvantage to the compound engine if it is not able to burn all qualities of coal. It reminds me a little bit of the young doctor who was called upon to attend a patient who was in the last stages of consumption and desired very much to have some corned beef and cabbage. The doctor thought this patient would die very soon, and perhaps it would hasten his death, so he allowed him corned beef and cabbage. The patient began to improve and finally got well. Soon after the doctor had another patient of the German persuasion who was suffering from stomach trouble, and who, in the absence of the doctor, took corned beef and cabbage and died. Thereupon the doctor made this entry in his book: "Corned beef and cabbage cures consumptive shoemakers and kills dyspeptic Dutchmen." Now I think if the compound engine will not burn all kinds of coal it is not suited for the business of our roads. (Applause.)

The PRESIDENT—I have been requested to call on Professor Woods.

Professor A. T. WOODS—Taking up some of the points in the report which have been discussed, reverting to the diagrams of the rotative pressures, in the first place, those diagrams were obtained, as it states in the report, from indicator diagrams which are also given in the report. I am

responsible for the diagrams, and I would say that I did not know how they were coming out, because when I began, I simply took what seemed to us, and what seemed to the chairman of the committee to be good, representative indicator cards from those two engines. Then we worked them out with the weights of reciprocating parts as given us by the builders, and these are the results we found. They are good examples of what the locomotives did under those circumstances. As there are only nine or ten cards figured altogether, it is not safe to draw general conclusions, and they are given simply for what they are worth as illustrations. They do seem to show that the claim for a much more uniform rotative effort of the two-cylinder engine is not substantiated. In Table 7 of the report, it seems to me, the best illustration of what the engine did under those circumstances are the lines which give the tests with the compound at 200 lbs. and the simple engine at 180 lbs., with Braceville coal. There were eight or nine tests, I think, with each one, and those averages are given in coal per horse-power hour and water per horse-power hour, 22.9 one way and 17.5 the other. The water per horse-power per hour was 25.7 and 14.8. That seems to me the most fair figure to use in that case. The general averages for the different kinds of coal and different pressures are, it seems to me, not valuable Now, of course, some of the saving there is due to the higher pressure—how much it is difficult to say. In order to get some idea of it, I made a hasty calculation. Saying that we were cutting off at about half stroke with 180 lbs., you raise the pressure to 200 lbs. and cut off sufficiently early to take advantage of it, there is a saving of something like 10 per cent. In that case, if that would hold, it would reduce our saving on the compound, in both cases, in coal and water to about 10 per cent. Of course that would be due to compounding alone. It is not possible to make an exact calculation of the loss by condensation in the two cases. I do not include that at all. It was, I say, simply a rough estimate.

Another point which is mentioned in the remarks on the results of tests —the saving in coal per ton-mile and water and horse power, it seems to me that the horse-power basis is the only one on which we can figure. An examination shows that there is a great difference whether we use the ton-mile basis or horse-power basis, and as the horse power takes into consideration the speed and the ton-mile does not, it seems to me that is the proper figure to use.

Referring to some remarks which have been made in regard to the different types of engines, the cylinder surface exposed, etc., I think Mr. Dean's statement does not include everything; that while in the two-cylinder engine we may have less surface exposed to condensation we also have a smaller ratio between the cylinders and, therefore, less possible expansion, so that you may lose on one and gain on the other. I do not think it is safe to say that an engine with a large high-pressure cylinder is necessarily better on that ground.

I want to ask Mr. Forsyth in regard to the boiler pressure that he used in the tests that he gave?

Mr. FORSYTH—180 pounds I used with our own engine.

Mr. FORNEY—Referring to Prof. Woods' statement that he prepared those diagrams showing the rotative effect, I think—if I understood correctly—no account was taken of the inertia and momentum of reciprocating parts.

Prof. WOODS—That is just exactly what was taken into consideration. That is the point of the whole diagram—that if you leave out the weight of the reciprocating parts it affects the inertia. The effects of inertia of reciprocating parts are included in those diagrams for rotative pressures. They were not included in the diagrams of the total pressures on the pistons.

Mr. PULASKI LEEDS—I would like to say, in the first place, that I never realized how any expression of opinion would be construed as influencing a man's judgment, if he was put on a committee, until one of our most prominent members called my attention to a piece in one of our engineering journals, dated at Louisville, signed "Anti-compound," with the implied question, "Did you write it?" If any of you gentlemen have seen that and thought that Leeds wrote it, I wish to say to you that he did not, and that he does not indorse it in any way, shape or manner. No matter what my opinion is, the facts, as far as we can get them, will be presented and our deductions will be drawn as closely and carefully as can be, as we yield the palm to no man in the earnest desire for improvements in locomotive practice, whether it be through the compound or not.

We owe a great deal to the designers of compound locomotives and the advocates of the compound locomotives. Whether it will lead to placing the compound on a footing as a superior engine or not, the result will certainly be that we shall get a more economical engine, even if it is a simple engine.

I think Mr. Vauclain could have made a greater claim than he has made, if he had got the same results for his engines that I have got, on one road that was using a certain class of simple engines which were burning 13½ pounds of coal per passenger-car mile. They changed and put on a well designed simple engine. She reduced that consumption of coal to 6½ pounds. Suppose that had been heralded from one end of the country to the other as a result of compounding? I will say further, that the compound engine has taken the place of that simple engine of the best type, and has reduced the consumption of coal to 4.78, which is still a greater reduction. If he could have had these results of comparisons between his engine and the first simple engine that was got, he certainly would have been justified in making a claim away beyond what any of them have. As far as the strictures that have been put on the committee in regard to making an average test, our understanding was that we were not put there to make any fancy tests, or to corroborate preconceived ideas, but to see what were the best average results for the country. Now, then, if anybody wants any fancy tests, let them take any two of those tables and compare them where they do average as one against the other, and they have what they

asked for. We have given as near as we could what we considered fair, average work, to be done throughout the country, and we did it all on one road.

The other day Mr. Lauder said that our engines were stereotyped. Does this result, with one class of engines as against another saving about 65 per cent., show that they are copies of one another, or does it show that there is more careful designing, and that we as American Master Mechanics have not had to go abroad to get the talent to bring our engines to their present state of perfection as simple engines? If the compound comes to the front, we will have the talent here able and willing to design compound engines as well as simple engines were designed.

Referring to Mr. Forney's remarks, I would say that I make a practice of taking master mechanics over the road. I took one in particular over the road, and he found that one of the master mechanics had met an emergency in identically the same manner as he had done. He said: "Is it not peculiar how mechanical minds will run in the same channel?" I think that it is wonderful how the minds of damn fools, as Mr. Forney says, run in the same channel. (Laughter.)

My general manager has been very much interested in these tests, and when he found that I had got the data on which these reports were to be based, he said to me: "Well, what do you think of it?" I said: "It is like this, we are asked to pay from $750 to $1,000 or $1,200 extra for a compound engine. That engine makes 36,000 miles a year. We make an allowance in our repairs for a sinking fund to replace that engine when she is worn out. She will burn about, say, five or six cents' worth of coal per mile. Now, on her 36,000 miles she will burn $1,800 worth of coal. We will allow that we will make a saving of 10 per cent on that, or $180. Out of that we must take at least 6 per cent. on the $750. We must be preparing a sinking fund to renew these extra parts of $750 to $1,000, and, at a rough figure, we will call it $150 a year for interest and renewal of extra parts, leaving us $80 as a gain over and above the replacement of the extra parts. Now, if a man tells me that he would design a 30-inch piston and reciprocating parts of an engine with the same weight that he would for a 20-inch cylinder, I would say that we should send abroad for designers. When he tells me that he can overcome this moving weight, stopping and starting it at each end of the stroke without throwing an extra thrust, and consequently an extra wear on his engine, he tells me something that I do not believe. The consequence is that I think that our chances for saving are reduced to a very small amount." The efficiency of the compound locomotives is entirely governed by the circumstances and surroundings in which it is placed; that is to say, upon the uniformity of lading, ruling price of fuel, physical features of the road and similar influences.

In connection with this engine that I spoke of, that took the place of the simple engine on which we made such an enormous saving—some 70 to 75 per cent.—I will say that the first thing that struck me was, that she was pinching the babbitts out of her crossheads. I took the strains

and I do not want to give the results. But if any one will take the strains that are thrust on the crossheads, he will find that they are something enormous.

In conclusion, I will say that when any one talks about fancy tests, that this test which was taken with as little expense as possibly could be on the Chicago & Milwaukee road, having cost them over $6,000, I think it would be unreasonable to ask any more of the railroad companies than they have already given us.

Mr. J. DAVIS BARNETT—Since I last spoke on this subject, I have had no personal experience with the compound engine, and therefore I need not detain this convention. But I would like to ask the chairman of the committee to explain for me one item on Table VII. I have not had time to fully analyze this report. I was trying to get some understanding of it last night. Referring to Table VII, lines 27 and 28, I take it that experiment 28 is put in close comparison with 27 there, showing that the simple engine, with a higher pressure than the compound, gave an economy in coal consumption. That is how I understand 27 and 28. Going further down on Table VII to lines 42 and 43, which are there bracketed together, I infer that they are put in comparison one with the other. I see that the simple engine, having 200 pounds pressure, is negative there, so far as economy is concerned. Do I properly understand that table to read that the simple engine having 200 pounds pressure had a superior coal economy to the compound with low pressure, and yet when it comes to compare that simple engine with itself that she was not as economical using 200 pounds pressure as she was in using 180?

Through the president, I ask the chairman of the committee for information on that point.

The report is so full of interest that I feel sure that we are all going to take it home and analyze it and get to the bottom of it. It has very seldom been my lot to put my hand on so large a mass of valuable information, so carefully, accurately and conscientiously worked out. (Applause.)

Mr. GEORGE GIBBS—Mr. Barnett says that he has not had time to fully digest this mass of information, and I want to say that the committee also has not had time to do it fully. This table is made out to give all possible combinations of the two engines at the different pressures and under different conditions, and the economies as shown are exactly results of the figures on those different bases.

Mr. Barnett is perfectly correct in saying that engine 822, which is a compound, showed a loss at 200 pounds. I will say this, generally,—that the compound engine was not suited to haul the trains that were offered to it at 180 pounds pressure, and it is hardly fair to the compound to take the results at that pressure.

As to the simple engine at the two different pressures, that line on east bound trips certainly does show a negative economy at the higher pressure for the simple engine. In line 30 the simple engine gave an increase of 13.7 per cent. on raising the pressure.

My own impression, generally, is that we cannot conclude that there is any economical effect by raising the pressure of the simple engine. I am also not able to conclude that there is any economy in raising the pressure on the compound engine, provided she is suited to do her work at the lower pressure. The gain of economy by raising the pressure of the compound, I think, is largely due to her being more suited to handle the business at the higher pressures, and not the increase of cylinder economy.

I would like to say a word regarding some of the remarks which have been made in connection with this paper.

Mr. Barr—I desire to ask a question on this subject. I understand Mr. Gibbs to say that in lines 42 and 43, Engine 822 was not as economical at 180 pounds as at 200 pounds.

Mr. Gibbs—No ; not as economical at 200 pounds as at 180 pounds.

Various opinions have been expressed by the members in a kindly spirit regarding this report, and I wish to say a little more emphatically, that I personally had no idea of the difficulty of this contract that we undertook. We started to make a complete test of the compound engine. We attempted in the report to express our inability to cover the subject fully. Mr. Forsyth remarked that in making a test of this kind, our first object should be to eliminate variables. I take the same position that Mr. Barr does on this subject—that we want all the variables in there, if we desire to get at the economy which the engine will show in road service. The only variables that we had to leave out was the variable manner of handling the engine by the men. We selected the most careful crews that we could get—men who would work their engines consistently. But that does not represent—and we so stated—the economy that we would expect on a division, for either the simple or the compound. I have no doubt that we got better economy out of both engines than we would if we put them in everyday service, and we did not attempt to predict what economy would result from everyday service, year in and year out. That is something we are not able to show without a very long-time test. We did try to show the economy of the principle, but we left in all the variables which might properly belong to such a test.

Mr. Forney stated, as I understood him, that we want an engine that is able to burn all kinds of coal. The reports show that the compound is able to burn all kinds of coal. The compound engine gained 19 per cent. in evaporating efficiency by the change from Braceville to Pittsburgh coal. She showed less comparative economy than the simple, because the simple gave less economy in changing. The figures offered this morning for the economy of the compound engine do not bear out the conclusions of the committee in this respect. I am not able to explain that discrepancy, but I will say positively that I do not believe that, in our engines on our road, there is any more economy than is shown by the conclusions given by our committee. That represents the maximum to be obtained from those engines. It is an undoubted fact that we can pick out trips that will show, individually, larger economy, but, for all around service, it is not in it. (Applause.)

Mr. SETCHEL— I want to say that I have had no experience whatever in using compound engines, and I think an expression of opinion without some experience is not of very much value. But, of course, I have, and am entitled to my theoretical opinion, although I do not care to give it at this time. The Pittsburgh Locomotive Works, which I have the honor to represent, have no compound locomotive in service, but I want to say that we expect, as the saying is, to be in the swim. We are constructing a compound locomotive, and we expect, by giving an increased heating surface and grate surface, and very much larger boiler, and other advantages, to show a saving equal to any of our competitors.

Mr. D. L. BARNES—In respect to the tests given in this report, I would like to say that they represent sixty tests, made in the most accurate manner that any tests have ever been made in, and if we cannot draw conclusions from these sixty tests, then the use of all fine apparatus for testing locomotives is in a pretty bad way. I think, if any one will examine carefully all the conditions that are so well given in this report, he will be able to draw some valuable conclusions. If not, the only thing to do is to have a long-time test under running conditions.

A statement was made here about the saving on a certain engine on the Adirondack road, and I would like to call attention to that statement, because it emphasizes some of the analyses I have made of other tests. There was a saving of 30 per cent. in coal per ton-mile. That is the final saving, but in the firebox there was a saving of 45 per cent. Now, the other 15 per cent. must have been lost by the compound system, if logical reasoning can be applied to the results given us. The same paradox can be found from a great many tests that have been published.

If you subtract from the saving per ton-mile the saving in the firebox, you get a negative result, which will indicate that if you should improve the combustion in the simple engine it would beat the compound engine. There is something wrong in such results, I believe, and that is clearly shown by the results the committee have given on these diagrams.

Another speaker has claimed 30 per cent. economy for the compound engine, but in that case he had 25 or 30 pounds greater boiler pressure, and did not mention it. I do not believe that is fair to the simple engine.

As far as the theoretical saving of the compound engine is concerned, it is not due to the lesser amount of cooling surface, but to the decreased range of temperatures in the cylinders, and that should be borne in mind. Most of the compound engines have greater cooling surfaces, they have larger ports and the surfaces of the ports are very large in proportion to the capacity of them.

About the oscillation of the compound, it seems to me that it is all dependent on the method of balancing. On the elevated road in Chicago, where, of course, an engine must be well balanced, we have twenty engines running, and they run as steady as any simple engine could, up to a speed of 40 miles per hour. If it is true, as the committee has stated, that these tests shown on the wall are the result of comparing a simple engine, with

sufficiently large cylinders, with a compound engine, with too small cylinders, I think it is a point that should be borne in mind in making analyses. Perhaps the compound would have shown better if it had cylinders the proper size.

Mr. C. E. SMART—The subject seems to have been very thoroughly discussed, but in justice to myself and the Michigan Central, I will say a few words. I have been asked a great many times why it is that the Michigan Central, having had two compounds, did not continue to build compounds, or to buy them. Now there are several reasons why, and the principal reason is this: We find that in order to get the very best results from a compound engine, it is necessary that the engine should be worked to her maximum capacity. I believe that is the experience of those who have tested the compound engine. Now that being the case, if we, on the Michigan Central, were to have fifteen or twenty compounds, they would be running in one direction, perhaps, heavily loaded, and in the other direction their load would be reduced one-half or two-thirds. In the one case they would make a gain and in the other case the gain would be neutralized on the return trip. That is one reason. Another reason is that we are about to go into a heavy business; the World's Fair is coming on, and we are using every effort to get our power into the best possible condition, and for that reason we do not wish to put compound engines, or a great many of them, into service and into the hands of inexperienced men.

Now I have never claimed to exceed 12 to 18 per cent. saving for the compound, even under the most favorable circumstances. A short time ago we made a test on the Canada Southern—or rather it was worked up by the train department, and it showed a saving of 16 per cent. There was a saving in water of only 7.4 per cent. as compared with 16 per cent. in fuel. That test extended over a period of some four or five days and covered 892 miles. There were forty-five cars on each train and the cars were passed over the scales and weighed and the weights given.

There were some remarks made here yesterday to which I would like to refer. Mr. Lauder stated his experience in regard to the exhaust—the size of the exhaust. I can agree with Mr. Lauder in almost every statement he made, excepting where he spoke of using a smaller exhaust. On our simple engines we used 4½, in some cases 4¾; but in the compound we have no difficulty in using 5¼ inches. That gives the compound engine an advantage. We worked with nozzles from 4¾ to 5¼-in.

Mr. Vauclain made the remark in regard to the repairs that might be necessary on the intercepting-valve that there might be a necessity for repairs there which would make additional expense over the simple engine, but in other respects he could not see that there should be any great increment. So far as engine 284 is concerned, which we have had running between two and a half and three years, all I can say, regarding the intercepting-valve or the repairs to it, is that I have every reason to believe there is an intercepting-valve in there, because I examined it on the floor in Schenectady and I presume it is still in there, but I have never seen it since,

and it seems to me it has been doing just as good work as it ever did. I cannot understand why it should not. There is a valve as nicely adjusted as any engine with its packing, and it does not move once while the piston of the engine moves five hundred thousand times, and why there should be any difficulty there I cannot see.

As regards the life of the firebox in compound engines, our experience is where we have taken the set of tubes out of the simple engine while the compound has been going on without any leak, or call for change.

Mr. R. H. SOULE—I think that the Norfolk & Western Railroad, during the last six weeks or two months, has really had a very exceptional experience in this matter of compound locomotives. In the early spring, the managers of the Norfolk & Western property found it necessary to add to their locomotive equipment in connection with a contemplated extension of the line. In that block of additional equipment there were to be fifteen passenger engines. The different builders were invited to compete. We submitted plans and specifications of the best type of engine we had for the service, a ten-wheel passenger engine. The result was that the Baldwin Locomotive Works was awarded the contract for those fifteen engines. But in sending in their bid they very slyly inserted alternatives there. They gave us a price on a simple engine such as we asked for and on a compound engine such as they would like to put in. After a good deal of consideration it was agreed that we should take five of these simple engines at once and have them made compound. The Baldwin people agreed to rush them through their shops and give us the benefit of them as soon as possible. We were then placed under instructions to give our opinion on this question in one month after these engines had been put in service, in order that it might be decided what the remaining ten engines should be. So we put the engines to work and placed them in competition with an equivalent number of simple engines of the same type and in exactly the same service.

The compounds were generally similar to the simple engine, but the Baldwin people were authorized, of course, to make such changes in the design as were necessary to introduce the compound principle and to secure any legitimate advantages, and taking advantage of that liberty which we gave them, they increased the strength of the boiler—not its diameter, not the number of flues, not the proportions of the firebox—they increased the strength of the boiler so that the pressure might be run up to 185 pounds against 160, I think it was, that we were carrying. But incidentally they also wanted to increase the diameter of the driving wheels in order to get the corresponding benefit of slower piston speed and slower valve speed and better distribution and action of the steam; and in introducing the larger wheels it was necessary to lengthen the engine a little—ten inches, I think; and, necessarily, that ten inches of length was added to the flues. Those were the conditions. We did not consider the ten inches increased length of flues any advantage to the compound whatever, because I think it has been clearly demonstrated long ago that the large proportion of evaporation due to flues occurs at the firebox end. Therefore the increased

advantage which the compound engine enjoyed from the greater length of flues may be disregarded.

I will say, in the first place, before I give the results of the test, that we distributed these engines on the two general divisions of the railroad so as to get results from two independent sources. The results were watched by careful men and reported, they simply reporting the performance of the engines, the trains that they hauled and the total amount of coal consumed, but not taking any account of the water evaporation. We also, during the last week of this period, had a close test made of performance throughout —coal consumption and water evaporation, and we received reports from those three different sources and averaged the results. We found a saving of 20 per cent. in fuel and 10 per cent. in water as compared with the simple engines, and as we had to make a decision on the lot, we recommended that the additional ten engines be compound. With us it was simply a question of compound against simple engines. We had no option whether it should be the Baldwin compound or any other. But we took the Baldwin compound, not because it was the Baldwin compound, but because it was a compound engine, and we thought we had demonstrated and we were safe in assuming that there would be an advantage to the railroad company in using the compound.

Now as regards the discussion here, it seems to me that there are two factors in this matter which have not been reckoned with sufficiently. One of them has been touched on by the last few speakers. It was alluded to by Mr. Barnett, I think, and then again by Mr. Gibbs and Mr. Barnes; and that is the fact that in advancing the pressure you carry in your boiler you reach your limit in the simple engine long before you do in the compound. My impression is that it is on record somewhere on pretty good authority that the most economical point of cut-off for the simple engine is between three-tenths and four tenths of the stroke. If you advance the cut-off you lose, simply because you do not take the benefit of expansion. If you cut off earlier than that you increase your condensation in the cylinder. That is, you condense water in the beginning of the stroke at high pressure and re-evaporate at the end of the stroke at low pressure, and you lose the difference in those pressures, and the only possible advantage in increasing the working pressure on the simple engine will be the possibility of cutting off earlier, and I think that Mr. Gibbs' figures and the general information which is on record on this subject lead us safely to the conclusion that we have about reached the limit of economy in the working pressure of the simple engine. I think common practice has run those pressures up to 160 lbs., and I doubt very much whether we can advance them much further in the simple engine. Therefore I want to answer the point made by Mr. Forney. He claimed that he believed that in every case where the compound engine had been given the trial it had been given some advantage, and I think he included that. I do not agree with him on that. I think the advantage of carrying higher pressures should be given to the compound engine every time.

Another thing has not been alluded to here at all, and that is this: If it is true that one of the advantages of the compound engine is that she will do the same work with less fuel, then the converse of that must be true, to a certain extent—if she will do the same work with less fuel, she will do more work with the same fuel. I do not know that we can prove that a compound engine can be made, under forced combustion, to consume just so much coal as a simple engine of the same size. I do not think we can prove that. But I do believe there is an advantage in there which is going to appeal very strongly to our transportation officers. We have looked at it entirely from the motive power standpoint and the standpoint of economy of operation as expressed in pounds of coal consumed per unit of work done. But beginning with the engineers--if engineers, train despatchers and superintendents gradually find out that they can get a little more work out of a compound engine of given proportions than out of a simple engine of the same proportions, they are going to be a battalion in favor of the compound. It can get that advantage in two ways: If it is deemed that it is legitimate to count on increased pressure in the compounds, assuming that the piston areas are the same, then we can assume that the compound will start more carefully from a state of rest than the simple engine. On the other hand, if it is true that the compound engine will do more work with the same fuel, then, having started the train, the compound engine will also move it over the road faster, because you can make your steam go farther. You can either use it at a decreased cut-off for the same speed, or at the same cut-off for an increased speed. When the transportation officers of our railroads wake up to this thing and find that they are enjoying an advantage of that sort, I anticipate that they will enlist themselves on the side of the compound engine and that you will have an almost irresistible influence that is going to carry you right along in that direction.

During this discussion I have been reminded of what is on record in the history of science, and that is when away back in the thirties, Dr. Lardner, one of the most distinguished scientists of that day in England, proved conclusively, to the satisfaction of the English public, that it would not be possible to build a boat large enough to carry enough coal to take it across the Atlantic Ocean. You all know how completely that has been refuted. I feel very much as if the future historian of this association, in digging up the records, might say we were a second edition of Dr. Lardner if we went too strongly against this improvement. I feel it in my bones that it is just as sure to come and displace the simple engine as possible. Instead of feeling any reluctance in tackling this problem, I think that we ought to throw all our energy into it.

Mr. Lauder—I move that the discussion of this subject be closed. Motion carried.

The next question taken up was the report, read by Mr. Forney, of the Committee on the

Status of the Car Coupler Question.

Among the duties imposed on your Committee was that of representing this Association at a meeting of another committee, appointed by the Railroad Commissioners of the various States to frame a law for the better protection of railroad employes from accidents and danger. A meeting of the latter committee was held in the city of New York during last winter, and representatives of the different railroad associations were invited to appear at the meeting.

Three members of your Committee were present at that meeting. The position which was taken and argued by your representative on that occasion was that any legislation by Congress to compel railroad companies to adopt any kind of automatic coupler was at present inadvisable. Owing to the great diversity of opinion among those who represented various associations at that meeting, the committee which was instructed to frame the law to be presented to Congress could not agree, and consequently no such law was framed, although several of the individual members of that committee submitted proposed laws of their own to Congress.

The Committee of the M. C. B. Association of Coupler Standards and Limits, with which your Committee was instructed to co-operate, have made a report at the recent meeting of that Association, a copy of which is submitted herewith. This report, it is thought, has substantially the scope which your committee was expected to cover in its report. The report referred to was received by the M. C. B. Association, and its recommendations were adopted. In addition thereto, another committee, consisting of Messrs. J. M. Wallace, John Gibbs, Wm. Garstang and E. Chamberlain, was appointed to make tests of couplers and report at the next meeting. The Secretary of that association was also instructed to communicate with the Interstate Commerce Commissioners and ascertain whether that commission could have the tests made at the Watertown Arsenal.

The Executive Committee of the M. C. B. Association have procured gauges for the preservation of the contour lines and thickness of the metal of the M. C. B. coupler, and these gauges are to be submitted to letter ballot for adoption as standards of that association.

Your Committee suggests that no other action of this association seems to be demanded at the present time, excepting to approve of what has been done by their sister association.

GODFREY W. RHODES,
M. N. FORNEY,
R. C. BLACKALL.

DISCUSSION ON CAR COUPLER REPORT.

On motion the report was received.

Mr. FORNEY—Perhaps a little more might be said in addition to the report. This subject of couplers has been taken up by the Master Car Builders' Association, and there is every reason for believing that it will be treated very thoroughly. They have taken action in the matter of gauges. They propose to have tests made during the coming year. It seemed to your committee that any action on our part would tend more to retard than to assist what would be done. We felt that nothing more could be done by this association at the present time. Perhaps a year hence, when the Master Car Builders have completed what they are doing, some action on our part will be needed.

A MEMBER—I move that the report be returned to the committee, and the committee continued another year.

Mr. LAUDER—It seems to me that we had better get through with the question that is now before the association. The committee have made a report indorsing what our sister organization has done in this matter of car couplers, and I do not think it is proper for us to discuss it at all or to continue the question any farther, as the matter is entirely in the hands of an organization that is amply able to take care of it, and anything that we might do might retard the adoption of a uniform coupler more than we might help it, and it seems to me there is no reason why we should continue that as one of our subjects for any further consideration.

Secretary SINCLAIR—I move that the discussion be closed.

The motion was carried.

The next business was the report on Tests of Steel and Iron.

This report was read by Mr. BARNES, as follows:

TESTS OF STEEL AND IRON.

Your Committee appointed to investigate the critical temperature of iron and steel, also any other questions relating to steel and iron that the Committee may consider of value, beg to report as follows:

A number of tests were made to throw some light on the matter of what is known as the critical temperature of steel, it being

generally understood that at a blue heat, or at a temperature of about 600 degrees, steel is extremely liable to crack in bending.

The experiments of your Committee demonstrated that this is a fact, and that steel that will bend when cold, or at a red heat, is extremely liable to crack when bent at a temperature varying between 500 and 800 degrees.

The results of these tests are given in table No. 1, attached to this report.

In this table the different makes of steel are designated by letters from A to I. The temperature at which the test was made is shown in the column marked "Temperature." Under the head of "Results" is given the condition after bending. In making these tests, the steel was first bent to a right angle, or 90 degrees, and then hammered down until it began to give decided signs of cracking; if no cracks appeared, it was hammered down so that the sheet closed on itself, which is designated by an angle of 180 degrees.

In a number of cases cracks did not begin to appear until just about the time that the sheet was bent to 180 degrees.

It is not thought desirable to give the names of the different steels tested, but the lot marked "A" was taken from an old firebox which cracked badly, and was removed after ten months' service. It is of the same make as the lot marked "F." It will be seen from the tests that steel which had been in a firebox but had cracked after making a short service, gave, in some cases, very good results in the bending test at 600 degrees, and also at 800 degrees, and cold. It will also be observed in looking over these tests, that while some steel cracked at 800 degrees, others did not, and also the same steel in some cases cracks at 800 degrees, while the second test, made at the same temperature, does not show any cracks.

Your Committee was inclined to be of the opinion that, if steel tested at the blue heat stood the bending test without cracking, there were strong probabilities of its being a good material for firebox purposes. However, an observation of the tests, as shown in the table, indicates that this position cannot be maintained. This is further shown by the fact that old firebox steel, marked in the test as "A," stood portions of this test better than some

new steel of the same make, and also better than some new steel of other makes.

The conclusion of your Committee, from tests made, is, that steel which stands a bending test at a blue heat, does not necessarily give material which can be depended on not to crack in service.

It was suggested that iron plates, on account of the tradition that they were less liable to crack in the firebox, would resist fracture at a blue heat better than steel. Your Committee accordingly made a number of experiments of the same kind with the samples of the best iron boiler-plate made in this country and England, the result being that at a blue heat the tendency of the iron plate to crack was decidedly greater than is the case with steel. This, in the opinion of your Committee, corroborates their position that the bending test at a blue heat is not a criterion on which to base an opinion of the suitability of material for firebox purposes.

The tests of steel at a blue heat, as referred to above, do not really introduce any new information so far as the fact of the liability of steel or iron to crack at a blue heat is concerned, but the tests, as shown, would seem to imply quite clearly that material which will stand this test is not necessarily good material, and it also illustrates the importance, in handling any material of this kind, of working it either cold or at a red heat.

The samples tested were heated in muffles in a specially prepared furnace made of fire-brick, drawing of the same being attached to this report and marked Figure 1. The temperature was taken by a pyrometer in the lowest and hottest muffles, and by thermometers in the muffles occupying higher positions. It was found that by this means a very equal temperature could be maintained, and your Committee believes that the figures, as given in the report for the temperature of the pieces when tested, is very nearly correct. When the pieces were removed from the muffles, they were quickly bent at right angles, the time consumed being about thirty seconds, after which the bending was continued by hammering the ends together until the fracture began to manifest itself.

ETCHING.

A number of tests were made by etching new and old steel, the etching mixture being diluted sulphuric acid. Some quite in-

teresting results were obtained from this. The etchings of all the new steel showed a decided uniformity of structure in the same pieces, except where laminations occur, but there is quite a difference in the appearance of the etchings of different brands. Some

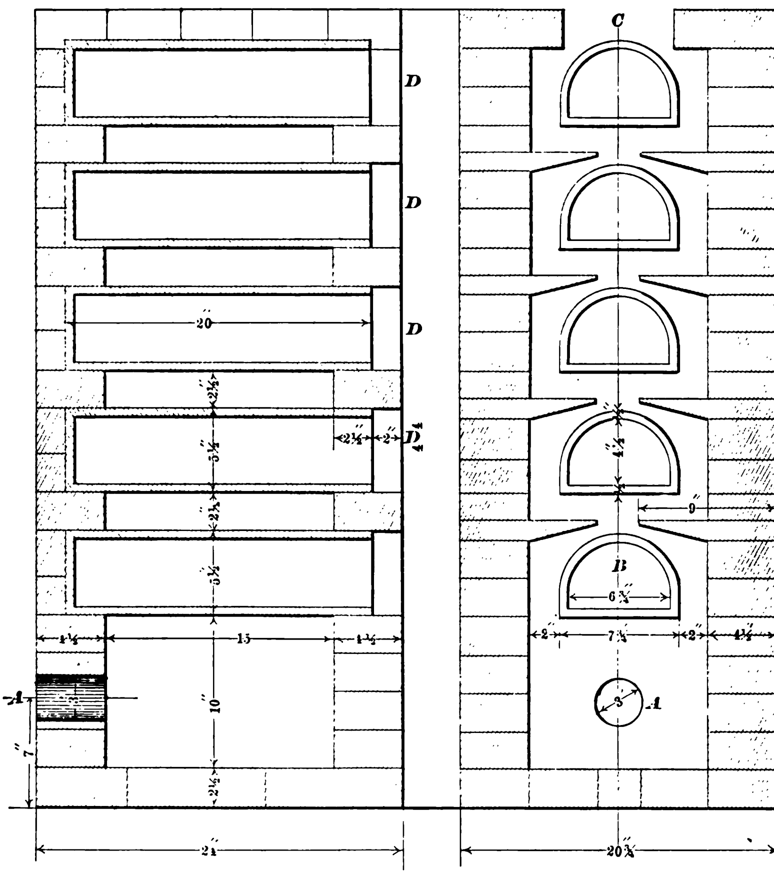


Fig. 1.

were much more quickly attacked by the etching fluid than others, and appeared to be coarser in grain. The most interesting results were observed in etching steel which had been in service in fire-boxes. In several samples of steel three-eighths of an inch thick, there was a decided difference shown in the structure

of the middle portion of the steel as compared with the two outside edges, there being a zone through the center of the piece about an eighth of an inch wide which the etching fluid attacked most actively. The outer eighth of an inch on either side showed but little more effect than new steel, while the inner eighth of an inch was spongy and appeared to be an entirely different material. The print of the most pronounced sample, which was only two years in service, is attached to this report, and shows clearly the phenomenon described. See *A*, Figure 2.

A number of tests were made of old sheets varying in service from 80,000 to 600,000 miles, and some of the pieces which had only made 80,000 miles showed more of a disorganization of the interior of the sheet than the samples which had made 600,000 miles.

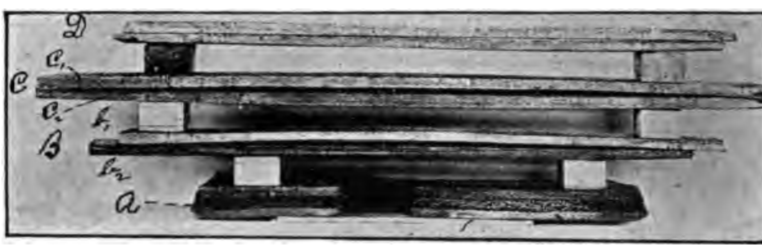


FIG. 2.

Unfortunately, it was not possible to obtain etchings of these sheets when they went into service, but your Committee is of the opinion that this phenomenon would not have been observed in the new sheets. Further tests should be made of new sheets, and of the same sheets after they have been in service, to establish this point.

The spongy interior of several of these pieces was carefully removed by a narrow tool, leaving the outside and inside of the sheets, about one-eighth of an inch in thickness, intact. Of these two pieces, the one next the fire sprung inward towards the fire about one-sixteenth of an inch in a length of eight inches, forming an arc of a circle; the one next the water remaining almost perfectly straight.

This phenomenon, perhaps, indicates a permanent expansion of the sheet on the side next the fire.

Your Committee was of the opinion that in cutting out the central portion of the sheet it might have been strained by the action of the tool, and to verify this point a piece of new steel was cut and split in the same manner; this showed no camber whatever.

It has been claimed that annealing a sheet would restore it to its original condition; with this object in view your Committee took a piece of the same sheet, carefully annealed it by heating to a red heat, then placing it between two pine boards and allowing it to remain until cold. The center was then cut out as in the other cases, and the result was the same as with the piece not annealed. This apparently clearly demonstrates the fact that annealing an old sheet of steel does not restore it to its original condition.

If there is a similar set or permanent expansion in the ends of the stay-bolts next the fire, it may be that it somewhat accounts for the cracks radiating from the stay-bolts, which are so frequently found in steel sheets.

It is impossible to say how much influence the apparent internal disintegration described above may have on the life of the sheet, but it was observed that some firebox sheets which had made a service of 600,000 miles did not show as much susceptibility to the action of the etching fluid as some other sheets which had made a service of only 80,000 miles, and which then cracked badly.

The idea has been advanced to us that the chemical actions of the fuel and waters may have a decided influence in shortening the life of firebox sheets, but we have made no investigations to determine this.

The facts as stated above in brief are as follows:

1st. There is apparently a disintegrating action taking place in the center of the sheet.

2d. The side next to the firebox seems to be permanently expanded, giving it a camber when set free by being sliced off from the rest of the sheet.

3d. Annealing after service does not remove this phenomenon.

4th. The above phenomenon may be a strong argument in favor of thin sheets.

STEEL TUBES VS. IRON TUBES.

The information as to the relative merits of steel and iron for boiler tubes has excited considerable discussion, but your Committee has very little definite information to present.

We are, however, advised that in the case of a large number of steel tubes the results, so far as wear is concerned, have

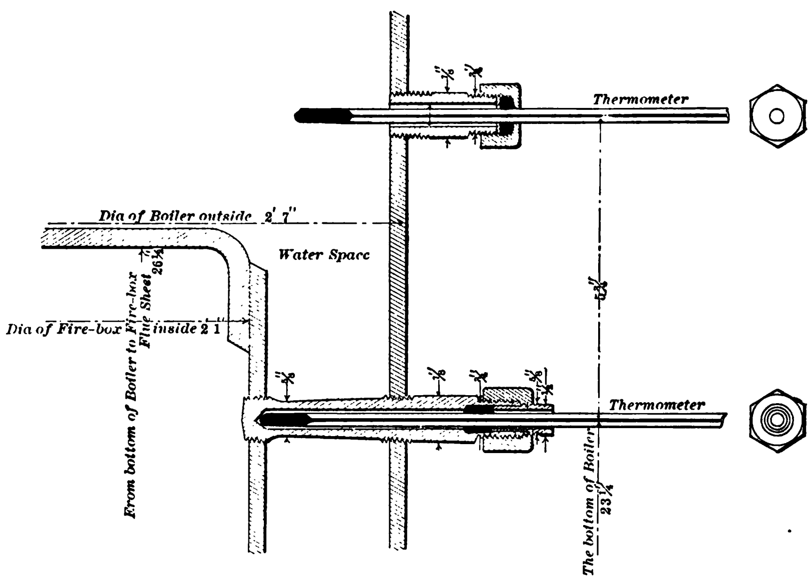


FIG. 3.

been unfavorable. The following definite experiment, however, has been made: An engine was equipped with 114 iron tubes and 113 steel tubes on December 20th, 1890. The iron tubes were placed on one side of the center, and the steel tubes on the other side of the center of the boiler, the flues being divided by a vertical line through the center of the flue-sheet. On March 9th, 1892, the flues were all removed. Seventeen of the iron tubes were condemned on account of pitting and corrosion, while sixty-four of the steel tubes were condemned for the same defect. This

would indicate that steel tubes are more affected by corrosion than iron ones. Further experiments and information in this line, however, is desirable in order to fully settle this question.

TEMPERATURE OF FIREBOX SHEETS.

In order to determine the temperature of a sheet in a firebox when the engine is being fired up, an experiment was made with two thermometers located as shown by the accompanying drawing, Figure 3.

One thermometer was placed in the water space and the other in a drilled stay-bolt, with the bulb at the inner sheet, as shown. The boiler was a stationary vertical one, and was fired with oil and rosin wood. The maximum difference in temperature between the water and firebox sheet, as shown by the thermometers, was about twenty-five degrees.

STAY-BOLTS.

In the matter of stay-bolts your Committee has very little to present; an endeavor was made to devise an apparatus that would represent a stay-bolt riveted into the sheet, to be subjected to vibrations in order to determine which material would resist the greatest amount of vibration. The apparatus in which the test was made is shown in Figure 4. This arrangement gives in vibration a full motion of three thirty-seconds of an inch at the end of the stay-bolt, and at the same time allows a stress in the direction of the length of the stay-bolt somewhat similar to that which occurs in boilers, the strain put on the stay-bolt being equivalent to a pressure in the boiler of 150 lbs. per square inch. A test was made in this way of four pieces of mild machinery steel; the average number of vibrations before breakage was 21,539, the pieces standing respectively 7,950, 96,060, 14,168 and 54,358 vibrations before breaking.

Eleven samples of iron were tested in the same way, the average number of vibrations before breaking being 6,568, the lowest being 3,120, the greatest 12,480. The result of these tests would indicate that steel is a better material for stay-bolts than iron; at the same time the experience of a number of members of your Committee with steel stay-bolts has been seriously against them.

They failed in service, and deductions drawn from the test, as made, are entirely misleading. Your Committee does not feel that in this they have added anything to the subject of a proper method of determining the suitability of any special material for stay-bolts.

The investigation, as described above, is not sufficient to enable your Committee to offer any specific directions for drawing up specifications for iron and steel for firebox purposes, and they

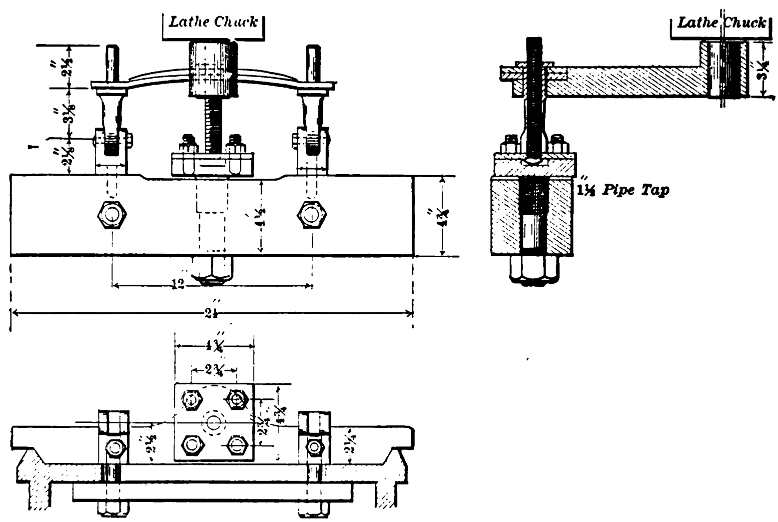


FIG. 4.

therefore have in this particular no definite recommendations to make.

The results of the investigations so far may be summarized as follows:

1st. Steel or iron should not be worked at a temperature between a normal temperature and a perceptible red heat.

2d. So called "blue heat" makes steels and irons more brittle, but some are apparently less affected by the "blue heat" than others.

3d. The test of steel or iron at a "blue heat" is not a criterion by which to judge of the action of the same in a firebox.

4th. Iron at a blue heat is more seriously affected than steel.

5th. There is apparently a mechanical disintegration going on in plates exposed to the action of fire, water and scale in a firebox.

6th. Steel tubes do not seem to be as durable as iron tubes.

Your Committee recommends that, owing to the importance of the subject and the great value to railroads of further knowledge of the relative merits of iron and steel, this subject be continued for another year at least, and that the co-operation of all members of the Association be asked in order that all experiments and experiences of the members be made available to hasten the acquirement of definite knowledge of practical value.

WILLIAM SMITH,
J. N. BARR,
A. W. QUACKENBUSH,
P. H. PECK,
D. L. BARNES,
Committee.

TABLE No. I.

Make.	Number of Piece.	Temperature. Degrees.	Thickness of Plate. Inches.	Results.	Angle. Degrees.
A	1	800	3/8	No cracks.	180
	2	"	"	Cracked.	170
	3	700	7/16	"	180
	4	600	3/8	Broke off.	90
	5	"	"	No cracks.	180
	6	"	"	"	"
	7	"	"	Cracked.	170
	8	500	"	"	180
	9	"	"	"	"
	10	400	"	"	"
	11	cold	"	No cracks.	"
	12	"	"	"	"
B	1	800	1/2	Cracked.	180
	2	600	"	"	160
	3	"	3/8	"	174
	4	"	1/2	"	137
	5	"	3/8	"	170
	6	500	5/16	"	180
	7	"	3/8	"	175
	8	"	"	"	180
	9	"	1/2	"	172
	10	"	"	"	170
C	1	800	3/8	Broke off.	90
	2	"	"	Cracked.	180
	3	700	"	Broke off.	90
	4	600	"	Cracked.	175
	5	"	"	Broke off.	90
	6	500	"	Cracked.	132
	7	"	"	"	155
	8	400	"	"	170
D	1	800	7/16	No cracks.	180
	2	600	"	Cracked.	170
	3	"	"	"	180
	4	"	"	No cracks.	"
	5	500	"	Cracked.	"
	6	400	"	"	175

TABLE No. I—*Continued.*

Make.	Number of Piece.	Temperature. Degrees.	Thickness of Plate. Inches	Results.	Angle. Degrees.
E	1	800	$\frac{5}{16}$	No cracks.	180
	2	600	$\frac{13}{32}$	Cracked.	"
	3	"	$\frac{5}{16}$	No cracks.	"
	4	"	"	Cracked.	"
	5	"	"	No cracks.	"
	6	"	"	"	"
	7	500	"	"	"
	8	400	"	"	"
F	1	800	$\frac{1}{2}$	No cracks.	180
	2	600	$\frac{5}{16}$	Cracked.	154
	3	600	$\frac{1}{2}$	"	170
	4	500	$\frac{5}{16}$	"	180
	5	500	$\frac{3}{8}$	"	175
	6	"	—	———	
G	1	800	$\frac{5}{16}$	Cracked.	180
	2	600	"	No cracks.	"
	3	500	"	Cracked.	"
	4	"	"	No cracks.	"
H	1	800	$\frac{11}{32}$	No cracks.	180
	2	700	$\frac{3}{8}$	Cracked.	"
	3	650	$\frac{5}{16}$	"	165
	4	"	$\frac{3}{4}$	No cracks.	180
	5	600	"	Cracked.	"
	6	"	$\frac{5}{16}$	"	"
	7	"	$\frac{3}{8}$	No cracks.	"
	8	400	"	"	"
I	1	800	$\frac{3}{8}$	No cracks.	180
	2	700	$\frac{13}{32}$	Cracked.	"
	3	600	$\frac{3}{8}$	"	90
	4	"	"	No cracks.	180
	5	"	$\frac{7}{16}$	Cracked.	146
	6	"	$\frac{3}{8}$	No cracks.	180
	7	400	$\frac{7}{16}$	Cracked.	170

Mr. LAUDER—I move that the report be received and the committee continued another year.

The motion was carried.

The PRESIDENT—Gentlemen, the noon hour has arrived. Has the Secretary anything to report?

STANDARD TREAD OF TIRES.

Secretary SINCLAIR—I have this question, "Is there any reason why the tread of the standard tire should be changed?" That was handed to me by a member who is not present, and I was given to understand that the necessity for bringing up the question was that tire makers receive orders for an immense variety of form of tires. It does not seem to be the impression among many of our members that we have a standard form of tire; many of them vary $\frac{1}{16}$th or $\frac{1}{32}$d from the standard size, or vary in a trifling way, where it would be just as well to make the tires the standard. There does not seem to be any reason why the standard should not be followed as well as the forms that are ordered. It would be better for the railroad companies, as well as the makers, if this were better understood, and I agreed to put the question before the association on these terms.

Mr. LAUDER—This is one of those questions that it is very difficult to control by any act of this association. When this association adopted standard sizes of wheel centers for locomotive driving wheels it was a decided step in advance, both for the railroads—the consumers of tires—and for the manufacturers. The main object was to enable manufacturers to carry tires in stock, so that orders could be filled quickly and correctly. The advantage gained by the manufacturers was that it gave them an opportunity in slack times to make up and hold in stock a large quantity of tires, knowing that they would be sure to sell them and not have any of them left on their hands. The advantage gained by the consumer was that the manufacturer carried his stock of tires, he being sure at all times of being able to receive tires at short notice, and not being obliged to carry large quantities at some considerable expense. Now it seems that there is another difficulty developed, which perhaps this association cannot control, and that is the section of wheel tread. This association adopted a standard section of wheel tread—adopted it, if I remember right, nearly unanimously, but now individual roads insist upon having their own particular section of wheel tread rolled; consequently they lose the benefits derived from having standard sizes, inasmuch as the tire makers cannot be expected to carry large quantities of their particular section of tire, although the diameter, thickness and width may be all right. Now, this is something which it is beyond our province to control. We cannot control the individual notions of the men at the head of the mechanical departments of the different railroads. For the sake of uniformity, and for the sake of getting the benefits which I have pointed out, I am willing to forego my notions in respect to the proper section or form of the tread and flange of the driving-wheel tire and adopt

some other man's, to a certain extent. Every one, perhaps, is not quite as ready, for the sake of uniformity, as I am, to do that. There is where the difficulty comes in, and I do not see any possible way of correcting this evil. It is more an evil, by the way, to the maker than it is to the user, for the user who suffers from this can easily get over the difficulty by changing his practice to the standard adopted by the association; while the manufacturer cannot do that; it is out of his power to change it, and he must make whatever section his customers order. I see no reason from my particular standpoint why any member of this association, any locomotive builder or any user of locomotive tires, should object to using the standard section of thread and flange adopted by this association. It may not be theoretically perfect in all its lines, but it is so nearly perfect that this association by nearly, if not quite, a unanimous vote adopted it, and it does seem to me that the benefits arising from an absolutely standard tire are sufficient to make every man who has adopted the standard diameters of wheel-centers come to the standard of section of thread and flange adopted by this association.

Discussion closed.

Discussion on Tests of Steel and Iron.

Mr. William Smith (Chicago & Northwestern)—I see several prominent steel manufacturers present and I would like to ask them some questions. I would like to ask the steel manufacturers what value they place upon chemical analysis in the manufacture of firebox steel.

Mr. Wellman (Wellman Iron & Steel Co.)—From the manufacturers' standpoint I can say that the chemical analysis of steel is of the utmost value. We could not attempt to run our works for the manufacture of steel without daily and constant analyses, both of the raw material that we use and the finished product. But I would not want to depend entirely on the chemical analysis as showing me whether the steel was all right. We have got to have a combination of chemical and physical analysis, and even that does not tell the whole story.

Mr. William Smith—In reference to the chemical analysis of steel, I will say that so far as the chemical analysis is concerned and the component parts, it is not worth the value of the paper it is written on. I have got steel here at present that has made less than 50,000 miles in the firebox; the firebox was worthless and condemned and had to be renewed. I have got other steel that shows a poorer analysis which gives entire satisfaction. The same steel that I referred to has stood the physical test all right. But to my mind an etching test is better than either. Of course, chemical analysis is all very well, so far as phosphorus and sulphur are concerned, but so far as the wearing qualities are concerned it is worthless. I have some samples here that I wish to show the members. (The samples were handed about among the members.) It is not so bad on Eastern roads as on Western roads where we have such poor water.

Mr. CHARLES BLACKWELL—I, certainly, for one, protest against the statement made by Mr. Smith. I think that every steel manufacturer knows that without chemical analysis it is impossible to tell what he is getting, and if he does not know what he gets, no one knows what the result will be. It is necessary, as said before, that the physical test should be combined with the chemical test. I think it would be rather a difficult matter for Mr. Smith to say that the two sheets or the two fireboxes that he referred to received exactly the same treatment and were under the same conditions. I think it would be a very difficult matter for him to say so, and, unless the steel received exactly the same treatment, it is improper to draw conclusions or comparisons.

Mr. BARR—I would like to ask a question, somewhat in the line of Mr. Smith's question. If a steelmaker is making steel from material obtained from certain ores in certain localities and has been manufacturing steel right along in that way for years, and has demonstrated to the public that he is turning out a first-class quality of steel, can he then call in a chemist to analyze a deposit of ore from some other section and be satisfied that he is going to give his customers as good an article as he did previously, or the same article?

Mr. DOLBEER—I would like to ask if Dr. Huston is here. I would like to hear his ideas in regard to that.

Mr. BARR—I would like to have that question answered. There are a good many steelmakers here, and it is important.

Dr. HUSTON (Lukens Steel Co.)—I will answer that question, gentlemen, in this way—that no man can tell entirely by the chemical analysis what results he may get. It is only that he must have a certain chemical analysis to produce a certain article, but that analysis will not always produce that article. There is one particular principle that I think all chemists will acknowledge, and that is the purer the ore, the softer it is, and the more rapidly it will wear and the more subject it is to chemical action, and I do not know but that the committee have run against that snag. It seems to me that in steel for a firebox the carbon ought not to be reduced too low. But I am sure that Mr. Wellman will bear me out in this—that every manufacturer will not only analyze the stock he uses, but of every heat of steel that he casts he will send a sample ingot into the chemist's laboratory and have it analyzed, and he will send a sheet into the physical laboratory and get a test of that. There is a difference, I know, as to the tensile strength; of that, you gentlemen will have to be the judges. It is like the old woman's pudding. We make the pudding and you eat it, and the proof of the pudding is in the eating.

Mr. SMITH—I would like to give Mr. Huston and Mr. Wellman each a piece of the same steel and ask them what the trouble was with it. It made less than 60,000 miles when it was cracked from one end to the other. Here are the samples I refer to, and here is the chemical analysis. (Mr. Smith handed the samples and the analysis to Dr. Huston.)

Mr. WELLMAN—I should say (answering Mr. Barr's question) that an

analysis was only an indication. If from our experience the analysis showed that the ore would make good steel, I should be inclined to try a small batch of it. I am not a chemist, but I think we could tell without fail from the analysis of an ore, if the chemist would give us a complete analysis; but he does not do that; they do not tell us more than half the story.

Mr. BARNES—As a member of the committee I would like to say a little about this report. Our chairman has said that he believed an etching will show more about steel than a chemical analysis. I believe he is right if he will go further and say that an etching will show the mechanical structure of the steel—that is to say, whether it has laminations or cracks. But so far as showing whether the steel is good for a firebox, or boiler, or tank-plate, I do not see how an etching can show that; because an etching of one good solid sheet of steel will look very much like an etching from any other good sheet of steel.

Referring to Figure 2 of the report, the result there shown is exactly what would take place if there was a very bad lamination in the plate. I heard of a case the other day where a brick had accidentally gotten into an ingot and they made a boiler-plate of it, and when they put it into the fire-box it cracked. The edge of it looked not much different from the picture A. I would hesitate myself to say—from what little I know about it—that the etching of a firebox-plate shows that it deteriorates in the center, or anywhere else after service. As far as the chemical analysis of steel is concerned, the chemists give us the exact amounts of the different elements in the steel, but they do not say, except in the case of carbon, in what way these elements are combined. For instance, they refer to "combined" and "graphitic carbon." One of those is a chemical combination with iron; the other is a mixture. But in the case of sulphur, silicon, manganese and phosphorus they do not say whether it is one phosphate of iron or another. But it is well known that one phosphate of iron will differ from another as much as iron differs from steel.

This question of lamination has been avoided by the committee, yet I do not see why it is not a very important one. We avoided it, I suppose, because we could not say anything about it that was valuable. In one case, one laminated sheet cost a locomotive builder last year $2,000. I suppose the steelmaker replaced the sheet for $15—a very small percentage of the total cost. In making specifications of steel sheets for fireboxes, something should be done to discover whether there are laminations in the sheet or not. Etchings on the edge will not show what is in the middle of the sheet. Some one has proposed a bending test, but you cannot bend a sheet to see the cracks and then use it afterward. Perhaps the only way you can protect yourselves against laminations is to hold the makers of the steel responsible. Steel has, in one case at least, been guaranteed for two years against lamination, with the understanding that the steelmaker should pay the cost of replacing bad sheets. If there is a lamination in a firebox-plate at first, it will always be there; if there is none when it is made, then there will never be any.

In regard to the test of stay-bolts, from examinations made since this report was put out, I am of the opinion that the reason there was such a wide difference in the results from the vibration tests, lies in the way the stay-bolts were fitted into the sheets. If you take a hard steel sheet and tap a thread into it with a sharp tap and then screw into that a soft iron stay-bolt which is a little larger than the hole, that stay-bolt will be ruined, because the hard sheet will cut into the stay-bolt and start a crack. A loose stay-bolt will, I believe, generally stand longer in service than a tight one, because it has a less bending strain. It only has to stand a tensile strain lengthwise. Whereas, if it is tightly fitted in the sheet, there is an extreme bending at first at the root of the thread in the outside sheet. Therefore I believe if those tests were repeated and care taken to have the hole in the sheet not too small, and the thread on the stay-bolt round at the bottom, with a corresponding rounding on the bottom of the tap for the sheet, I think the results would be more nearly uniform. I would say that one of the test machine makers is taking the matter up and is going to make a large series of tests to determine how to distinguish a good from a bad stay-bolt material.

Mr. William Forsyth—I have a word to say in regard to steel tubes which may be of some value. I agree with the conclusions of the committee in the fact that steel tubes do not seem to be as durable as iron tubes, and that has been our experience with steel tubes. The fact of the matter is, that steel blooms can be made a great deal cheaper now than iron blooms, and the tendency of the manufacturer is to supply steel tubes at the same price as iron tubes, and thus force them into the market. A steel tube, at the same price as an iron tube, I do not believe is as good. There may be steel tubes, solid drawn and seamless, which are as good as iron, but they cost a great deal more. In addition to the trouble from corrosion with the steel tube, we have found the trouble with the weld. It is very difficult to weld a steel tube and make it stand in locomotive service. So I will caution our members to look out for this matter when manufacturers try to give them steel tubes of an ordinary quality at the same price as iron tubes.

Mr. George Gibbs—I want to suggest a small point for the committee to work up in connection with their investigations on boiler steels, and that is investigating the physical properties resulting from two very characteristic cracks which are found in commercial brands of boiler steel on the market. These two fractures are, roughly, a granular and a silky one. The difference is very marked, and with the steels that we are in the habit of buying I can tell at a glance, without any mistake, where they came from by looking at the fractured test piece. Now the analyses of those brands are in all cases equally good from a chemical standpoint, so far as we know.

I would notice here what Mr. Wellman says about chemical analyses. I agree with him entirely. But there are two very distinct classes of steel, and it looks as if there might be a chance for a very different action in service. We are keeping now a very elaborate record of our firebox sheets, and hope, probably in a few years, to have some results from these two kinds. These

two kinds of steel give different results in etching, and the etching test is quite likely to give you erroneous results, unless it is carefully carried on. The same plate, the same brand of plate, will act very differently in the same acid, and without any apparent reason. I have not been able to make any etching tests which showed to my satisfaction that one plate was harder or softer than another.

There is one question here I would like to ask the committee. In this vibrating test they do not say whether this piece of mild machinery steel had a screw thread cut on it. I presume it did?

Mr. BARR—Yes.

Mr. SMITH—I will answer Mr. Gibbs that the staybolt test had a full thread, the same as an ordinary staybolt.

Mr. CHARLES BLACKWELL—The report of the committee shows that it is unsafe to base conclusions on one test from one piece of steel. There ought to be several experiments. In some cases I have tried at the same temperature, one piece would break and the other would not, and to corroborate that I have here two samples, each of which we tried to raise to exactly the same temperature. One broke almost in two, making a very bad fracture, and was not close together before that fracture was obtained. In the other case the sides were almost brought together and the crack was hardly to be seen. It shows that very little difference in temperature and other conditions will change results.

If in order, I would like to make a few remarks as regards the necessity for exercising care in the preparation of coupons for testing. It bears on this same subject, and if in order I would like to call attention to it. It may perhaps save some trouble hereafter.

As the necessity for the exercise of special care in the preparation of steel coupons for testing purposes is possibly not appreciated by every one, these remarks may be in order.

When coupons from steel plates are tested for tensile strength, elongation, and reduction of area, it is assumed that correct results are desired.

To obtain such it is absolutely necessary that the coupons be carefully handled, and not subjected to improper treatment.

They should be separated from the sheets by means of long bladed sharp shears so as to prevent distortion, which means a change in tensile strength and percentage of elongation.

Should the coupon be bent so as to require straightening by means of a flatter applied to its sides, little or no damage will ensue, provided care is displayed so as to use light blows only; but if the coupon is bent edgewise, or curled, from the use of shears with too short a knife, it is imperative that the piece be not struck upon its edge. It should be turned up upon a planer or equivalent tool, otherwise considerable deviation from correct results will follow, when pulled in a testing machine.

Examples showing difference in tensile strength, elongation and reduction of area of various makes of steel, and due to proper and improper preparation of the coupons cut from the same sheet, are shown in this table.

(Mr. Blackwell exhibited the following table :)

EFFECTS OF MALTREATING STEEL TEST PIECE.

No. of Sample.	Tensile strength per square inch.		Elongation in 8 ins., per cent.		Reduction of area, per cent.	
	Normal.	Abused.	Normal.	Abused.	Normal.	Abused.
1	56,600	57,600	25.0	10.8	55.5	50.0
2	57,000	59,000	25.5	15.0	62.5	54.0
3	55,700	57,000	28.0	14.7	60.7	56.0
4	55,800	64,000	25.0	16.25	60.0	59.0
6	51,600	54,000	29.25	....	65.0	59.0
7	55,000	58,100	22.25	12.5	60.0	54.0
8	54,400	54,600	25.37	21.0	62.0	60.0
9	54,500	57,000	29.25	1.	62.7	64.0
14	52,700	58,200	28.5	19.37	60.0	41.9

The experiments were made by the same parties, at the same time, and with the same machine, and the relative results obtained from coupons off the same sheet indicate to what extent the maltreated coupons were punished.

In some cases, little or no damage seems to have been done. The ordinary effect, however, of moderate punishment of the test-pieces, seems to be an increased tensile strength, a reduction in percentage of elongation, and a diminution of reduction of area. Sometimes sufficient injury is done to show a considerable reduction in tensile strength.

The error thus obtained is sufficient, sometimes, to condemn a good sheet, for excess of tensile strength, and deficiency of percentage elongation and reduction of area, and may cause serious delay to work in the shop before the cause is discovered, and satisfactorily explained to the consumer.

Dr. HUSTON—It is the accepted rule with all manufacturers now that a test piece should not be cut off with shears. It should be cut off with a milling machine or a planer. I have a sample with me showing the crushing effect of shears on steel compared with one that was afterward put through the punching test. Steel should never be cut with the shears. You may cut a wide piece and then you may mill or plane a piece out. But where the edge has been in contact with the shears, it is always ruined and will give you varying results.

Mr. BLACKWELL—I fully agree with the last speaker. I, of course, expect that the piece would be cut wider than it ultimately would be when put into the machine.

Dr. HUSTON—The form of the test piece and the thickness of the test piece will make a variation in test. If you take a piece that is perfectly parallel, it will show a lower tensile strength than if you shoulder out a 2-inch section. Some railroads use the 2-inch section, and that will show about 2,000 pounds more tensile strength. The United States steamboat inspectors adopt a section representing the rivet line; that will show about 8,000 pounds more tensile strength than the parallel. Then, the varying thickness will affect it also. A piece ¾ of an inch thick will probably show 2,000 pounds more tensile strength than one ⅜ thick.

The PRESIDENT—I noticed that you said, Mr. Barr, that these pieces were about the same thickness. My eyes, if they do not deceive me, would make about ⅛ of an inch difference—fully $\frac{1}{10}$ anyway.

Mr. SMITH—The thinner piece has run over 600,000 miles. I would like to ask Dr. Huston why those sheets give way in this manner. That is another sample of the beautiful steel we have.

Dr. HUSTON—They show the same thing, gentlemen. In casting this piece of steel, it had been piped, and in the process of rolling those pipes had been drawn out into these long cracks. This is the same thing exactly. If the steel had been solid, without piping, that would not have occurred. I want to say to you that I do not think there ever was a heat of steel cast in which there was not more or less of this. When we get it down to a minimum it does not show. I have samples which I sent on to illustrate some of these points, and they can be seen on Messrs. Coolbaugh & Pomeroy's table. I should be glad to show them to any one interested.

Mr. SMITH—I want to say that we have very bad water out our way, and we have had a great deal of trouble with fireboxes. We got ten engines from the Rhode Island Works in 1873. Those fireboxes had stood better than anything the company ever had. We have taken out two of them this year; that is about nineteen years' service, and all have averaged over 400,000 miles. The steel seems to be a very superior quality. I think it would be better for railroad companies to pay 50 per cent. more for steel and get better material than the stuff we are getting now from many of the makers. I know our company is willing to pay for it.

Mr. BARR—I will put these samples upon the table so that any one may see them. I would like to ask, if this difficulty is piping, if there is any method of inspection that we can establish that will keep us advised of the fact and keep us from piped steel. We do not want it.

Dr. HUSTON—The Pennsylvania Railroad, in inspecting all steel, take a piece and bend it, and that shows the piping.

The PRESIDENT—Do I understand that this piping would extend through the entire sheet.

Dr. HUSTON—It may be on only one side.

The PRESIDENT—In cutting a coupon, he might not cut out that piece.

Mr. SMITH—I would like to ask why this piping always occurs about the middle of the side sheets.

Dr. HUSTON—I suppose that is the hardest service and develops the piping.

Mr. SMITH—I am rather disposed to think that it is in the cooking of the steel more than in the piping.

Dr. HUSTON—I agree with you. If the steel is not properly cooked and brought to a state of rest, as near as you can get it before pouring it, you are going to have trouble.

Mr. O. STEWART—What are we to understand by that word "piping"? I confess I am ignorant as to its meaning.

Dr. HUSTON—Did you ever make a casting that had bubbles of air all through it?

Mr. STEWART—No, sir; I never made one; but I have seen castings with those bubbles all through them.

Dr. HUSTON—Well, as I say, there is a chemical action going on in the steel which develops these little bubbles, and if they do not get out in time the steel forms around them.

Mr. LAUDER—One statement made by Mr. Smith brings out a fact that we should all dwell upon, and that is that he has got, even with his extremely bad water, boilers that have given him from 400,000 to 600,000 miles service, covering a period of nearly twenty years. I think that is a very remarkable fact, that a firebox on the Chicago & Northwestern road, with their extremely bad water, should give a service of twenty years, while he produces before us here samples taken from a furnace that has run less than one year and is absolutely worthless, being cracked from some cause or other. Now to a layman like myself it seems that if twenty years ago the manufacturers of steel in this country could make a plate that would give us twenty years' service, they ought to be doing the same thing to-day. (Applause). In fact, they ought to be giving us better plate, because they ought to be progressing in their business, as we hope we are in ours, and to know more about the manufacture of steel to-day than they did twenty years ago. Possibly some of the fault lies with us. The average purchasing agent wants the steel that he can buy for the lowest price. Manufacturers well understand that, and if they cannot produce a steel to sell as cheap as the other man, on many roads they cannot sell any. Now I do not suppose there is a railroad in this country on which the mechanical man would not consider the question of price of secondary importance and the question of quality of the first importance. But unfortunately on many of these roads the matter is not settled entirely by the mechanical man. It is settled by some one who wants to make a good showing in his particular department, without regard to the machinery department, and if some fellow comes along with a glib story to tell and a lot of scientific tests formulated in a table and offers steel for a quarter of a cent a pound lower than some well-known manufacturer offers it, he gets the trade. What is the consequence of all this? It forces the man who has been making an

honest article, and making it intelligently, to come down to the methods of those who sell the steel cheaper than it can be made. Now I believe that instead of the price of steel for fireboxes of locomotives dropping all the time, it would be largely for the interests of the railroads if it were increased, if the increase meant a better product.

I think the facts produced here in this discussion should be scattered broadcast amongst the railroads of this country, and amongst the general managers and the men who are responsible for the financial results of the operation of our railroads. Just think of it for a moment: a new boiler costing from $1,500 to $2,000 is put into service, and in ten months torn all to pieces at a cost of I don't know how much, because some one has chosen to put in plate that is improper, while the neighboring engine doing precisely the same work has caused no expense to the owners. I tell you these facts have a broad bearing on the future prosperity of our railroads, and in the West especially, where they are cursed with bad water. This question of firebox steel is one of the questions that is probably as serious a one as they have to contend with—by far the most serious, perhaps. In my country almost any of the steels sold would give us good results, because if we take out a furnace in less than twenty years we think there is something radically wrong. I speak warmly about this thing, for my neighbors; I am not troubled myself; but I know the difficulty of operating boilers in the Western country with this extremely bad water, and I tell you the steel manufacturers and the railroads in combination ought to do something to eliminate this terribly destructive effect that the bad water has on the firebox of the locomotive, if it can be done.

Dr. Huston—Mr. Lauder has made some reflections on the manufacturer. I would like to make some reflections on the consumer. I admit all he says—that a very low priced article is by no means the cheapest, and we are all forced down entirely too far. We have either got to quit business or come somewhere near the prices that others are offering. But I would say that they are tying us down to a lot of physical tests. We are not allowed any discrimination in the matter at all. I do not think that the physical tests given out at the present day are the best. (Applause).

Mr. Smith—I am under the impression that all master mechanics and superintendents of motive power will co-operate with steelmakers in the effort to give them a better article, and will not bind them down to any specifications for steel. What we want is a good article, and I think a good many are willing to pay an advanced price, and those steelmakers who are willing to guarantee their steel can get, I think, a large share of the business. I think that first-class steelmakers ought to be able to give a guarantee with their steel if they are allowed a living price for it. Now I would say to you that last year we put in about seventy-five fireboxes on the Chicago & Northwestern road. We have got about 872 engines; and I think that is a very heavy percentage.

Mr. Gibbs—I would like to say one word more about that physical test. Dr. Huston has objected to specifications for physical tests. Now, there

are comparatively few roads in the country that do make any specifications of that kind, and that specification has been made in the first place on the recommendation of the steelmaker, and I have never heard, personally, in conversation with them, or from any published remarks of theirs, that they had anything better to offer, and I doubt whether they will agree any closer on what is the right thing than the railroad companies would agree on what is the right thing. Consequently that leaves us just as much at sea as we were before.

Another thing: if Mr. Lauder's fireboxes last twenty years on his road, it looks to me as if there was some doubt as to whether the same steel that answers the purpose in his case would answer in ours. It is probable that he gets the same steel that we do. What is the matter with our fireboxes, then?

Dr. HUSTON—I think the specifications too low. I favor 50,000 or 75,000 tensile strength.

(Remainder not heard.)

Mr. SMITH—The engines I have referred to have been running alongside of other engines. They have been from one division to another. They have had a share of all the waters we have on the system, and all the coal, and they have stood the test, while others have fallen down alongside of them, and although we do have bad water, it is evident that we have bad steel.

Mr. J. S. MCCRUM—I agree with Mr. Lauder and some of the gentlemen who preceded me, that the question of the price of steel is of secondary consideration, and I would like an expression from some of the steelmakers here as to whether they think they could produce a better material.

Dr. HUSTON—I will now state what I hesitated to state before. Some ten or twelve years ago the Hartford Steam Boiler Insurance Company wrote to me for a standard of steel that was best for stationary boilers. I gave them steel from 55,000 to 60,000 pounds tensile strength and not less than twenty per cent. elongation in eight inches. I asked them not long ago: "Now you have been trying this rule for the last twelve years, and thousands of boilers have been built under that specification; what is the result?" They replied: "Not a single complaint." That is my answer to your question.

Mr. JACKMAN—I can say, for Hussey, Howe & Company, of Pittsburgh, that twenty years ago we were making fireboxes, but the price has gone down of late years to such a point that we could not make enough out of them to induce us to stay in that line. So for the last few years we have not been making very many fireboxes. If the railroads of this country and the boiler makers would pay what we consider a fair price for that material, the successors of Hussey, Howe & Company would go back into the business. You will notice that we were making a good steel when Mr. Smith bought that material. (Applause.)

Mr. MCCRUM—Would the manufacturers be willing to guarantee their product for any given time—the number of miles run or the number of

years' service, and let them make it entirely as they want it? I would be willing to pay almost any price, up to ten cents a pound if necessary, for firebox steel. On Western roads, where the water is bad, the matter of the price of the material I do not think enters into the question at all.

Mr. L. R. POMEROY—I would like to say, that in the year 1884 we sold nine fireboxes to the Chicago, Milwaukee & St. Paul road under a guarantee of three years' service; that if they failed within the three years we would replace the steel and pay for the labor both ways. We have heard nothing from the company relative to those nine fireboxes, so we suppose that the material is satisfactory. I suppose they would be willing to make that guarantee again.

Mr. WELLMAN—As I understood Mr. Lauder, he asked the steelmakers if they could make any better steel than they are making. I have been making firebox steel some fourteen years. During all that time I have been trying to make the very best article I could possibly make, and to-day I am trying to make the very best thing I can possibly make. The price does not have any influence at all, and I can say that I believe we are making a better steel to-day than has been made in the last eighteen years. When I cannot make the best thing that can be made, when I cannot make the best firebox plate, or what in my opinion is the best firebox plate, then I am ready to quit the business. (Applause.)

Mr. Smith has some fireboxes on his locomotives that are giving 600,000 miles' service. I would suggest if you can get those old fireboxes taken out it would pay the Chicago & Northwestern road, and it would pay this association, to have the most elaborate physical and chemical analysis or any other analysis that you can have made, in any way, shape or manner, of those fireboxes, and find out, if possible, what the reason is—get all the information you can.

Mr. SMITH—I have had the last box taken out now, but have saved that box, and I am willing to give Mr. Wellman. Dr. Huston or any other steelmaker samples of this for any analysis they wish to make. I wrote the Rhode Island people about two months ago asking them if they had any statistics showing what steel they used in those boxes. They said they had no record of it. They said they thought that, at that time, they were using iron; but this is steel. Therefore I cannot get any information from the Rhode Island people. Perhaps some one else can get it. But I have got one of those boxes saved, and I am willing to give any steelmaker all the samples that he wants, so far as they will go, and let them carry out the test for their own satisfaction.

Dr. HUSTON—I wish Mr. Smith would send me a piece by express.

Mr. MCCRUM—I would be very much in favor of buying steel under a guarantee. I would like that guarantee to extend, however, to cover the cost of having to replace it in a given time. But a three years' guarantee I would not consider as anything like a reasonable guarantee.

Mr. FORNEY—I have heard this discussion, and, although I do not know anything about the subject, it seems to me, from what has been stated by

gentlemen heie, that the reason we do not get good steel at the present time is that railroad companies are not willing to pay enough, and that if railroad companies would only pay a sufficient price, we could get good steel. Now, it would be a very interesting fact, if it could be established here in this meeting, just exactly what price it is necessary to pay in order to get good steel. That would be a sort of test of the quality of the material that I should think might be of value to railroad companies.

Secretary SINCLAIR—The present tribulations are always harder to endure than those which are at a distance. There is a good deal of complaint at present about steel failing, but those who meet with those difficulties would do well to look back fifteen or twenty years, or even further, at the difficulties that were encountered at that time. Firebox sheets are subjected to tremendous hardships in service. It is very difficult to get any kind of material to stand satisfactorily. Everything in the way of metals has been tried for that purpose that could be purchased, and so far steel has been found most satisfactory. There has been of late years so little difficulty with steel that many railroad officers began to conclude that any kind of steel would do very well for firebox purposes. There is no doubt but that there is a great deal of cheap steel being made, and presumably inferior steel. The buyers have been inclined to think that it is good enough, and failure has taken place. It is well to keep up to the high standard, and remember that it has not been inferior steels, but steels of a very superior quality, that have made that material a success for the fireboxes of locomotives. Steel for fireboxes has been like iron for rails and many other things, as it began to get cheap it began to get bad, and I should wish to advise those who are buying steel to see that it is of the very best quality, and that it has the reputation of a good maker behind it, before they take it and put it into fireboxes.

Mr. O. STEWART—I move that the discussion of this question be closed.

The motion was carried.

The PRESIDENT—We will now take up the report of the Committee on Uniform Locomotive Performance Sheets.

This report was read by Mr. JOHN A. HILL, as follows:

UNIFORM LOCOMOTIVE PERFORMANCE.

Your Committee, appointed to investigate the subject of uniform locomotive performance statement, beg to submit the following:

First. We would recommend that all passenger and freight mileage be based on actual miles run, and five (5) per cent. to be added to all freight mileage; that all engines in construction or snow-plow service be allowed at the rate of ten (10) miles per hour; all engines in switching service be allowed at the rate of

eight (8) miles per hour, no percentage to be added to this class of mileage. All other runs of less than one hundred (100) miles freight or passenger, actual miles to be allowed, regardless of what engineers and firemen may be paid for such service. No extra mileage should be allowed going to and from the roundhouse. When an engine is assigned to more than one class of service, the mileage should be computed, so as to show each class of service.

Second. In the distribution of fuel, one (1) cord of wood should be rated as one (1) ton of coal, and all expense in connection with the handling of fuel, either wood or coal, to be included in the cost of same; all coal to be rated at two thousand (2,000) pounds per ton.

Third. In the distribution of illuminating oils, only such oils as are used in the head-lamps and lamps and torches belonging to engines should be shown on the performance sheets.

In the distribution of lubricating oils, we believe all oils used in lubricating engine, including that used in packing driving-boxes, tender and engine trucks, while engine is undergoing general repairs, should be charged to repairs. All lubricating oils used on engine after engine goes into service, to be charged on cost and performance sheets as lubricating oil against engine.

Fourth. In showing the miles run to one pint of oil, the engine, valve and illuminating oil should be separated, showing the miles run to one pint of each, and a separate column be made on engine's statement, giving the total average for all kinds of oil.

All waste used by engineers and firemen, and by wipers for wiping engines, should be shown on performance sheet, and the miles run to one pound of waste given. Waste used on engines while undergoing repair should be charged to repairs.

Fifth. In the apportionment of the expense of labor for repairs of engines, we believe no labor should be charged for repairs other than performed by mechanics, helpers, and those actually working on repairs; laborers, sweepers, sanding and turning table, cleaning round house andother outside work in and about roundhouse, should not be charged to repairs, but should be charged to locomotive service.

All undistributed labor, such as superintendence, clerks, etc., should be prorated over general shop expense. Cost of engine repairs, caused by accident due to other than engine failures, to

be not shown on performance sheet, but such expense should be kept separately, and charged to the department responsible for the accident.

Sixth. All new engines purchased or built to take the place of those worn out, should not be charged to repairs of locomotives. All general repairs of engines, including overhauling, etc., except the above-mentioned, to be charged to repairs, except the application or new devices, such as air-brake equipment, extension front end, steam-heating appliances, train signal or smoke consumer. We believe the application of these new devices should be charged to new equipment or betterment. In the charges for materials used on engines, including files, chisels, other small tools, and the engine's equipment, should be charged to repairs of engines. We would recommend the preparation each month of a performance sheet in detail for each division of the road, the same to contain the following information :

Engine No.
Name of engineer.
" fireman.
Mileage, each class separately.
" total.
Tons of coal.
Cords of wood.
Oil, each kind separately.
Waste, pounds.
Cost of coal.
" wood.
" oil and waste.
Wages of engineer and fireman.
" hostler, wiper, and miscellaneous labor.
Cost of material for repairs.
" labor for repairs.
Cost. total.
Cost per mile run for fuel.
" " " oil and waste.
" " " engineer and fireman.
" " " hostler, wipers, etc.
" " " repairs, labor and material separately.
Total cost per mile run.
Miles run to one ton of coal.
" " pint of engine oil.
" " " valve oil.
" " " lubricating oil.
" " " illuminating oil.

Miles run to one pint of all kinds of oil.
" " one pound of waste.
Average number of loaded cars hauled per train.
Average number of pounds of coal consumed per car per mile.

Engine No.	Names of Engineers.	Names of Firemen.	Mileage				
			Passeng'r.	Freight.	Constr.	Switch.	Total.

Tons of Coal.	Cords of Wood.	Total Tons.	Pints of Engine Oil.	Pints of Valve Oil.	Total Lubricating Oil.	Pints Illuminating Oil.	Total all kinds of Oil.	Pounds of Waste.

Cost of Coal.	Cost of Wood.	Cost of Oil and Waste.	Wages of Engineers and Firemen.	Wages of Hostlers, Wipers and Miscellaneous Labor.	Cost of Material for Repairs.	Cost of Labor for Repairs.	Total Cost for Repairs.

COST PER MILE RUN.

Fuel.	Oil and Waste.	Engineers and Firemen.	Hostlers, Wipers, etc.	Repairs. Labor.	Repairs. Material.	Total.

Miles Run to							Average Number of Loaded Cars per Train.	Average Pounds Coal Consumed per Car per Mile.
Ton Coal.	Pint Engine Oil.	Pint Valve Oil.	Pint Lubricating Oil.	Pint Illuminating Oil.	Pint all Oil.	Pounds of Waste.		

To place the rating of empty cars on a uniform basis, your Committee would recommend the following:

In figuring loads, all box, stock, refrigerator and furniture cars, 30 feet long or over, three empties to be considered equal to two loads; gondola and flat cars, two empties to be considered equal to one load.

GEO. F. WILSON,
J. S. M'CRUM,
JOHN PLAYER,
JAS. M'NAUGHTON,
JNO. A. HILL,
Committee.

Mr. SPRAGUE—I move that the report be received.

The motion was carried.

Mr. HILL—I want to say that this committee could not possibly offer anything new to this association. The idea, if we understood it right, was to offer to the association a mileage performance sheet that would be absolutely uniform, so that when roads exchange performance sheets they would not have to make, for this and that, different arrangements of charges, etc. If you take the performance sheet which is shown on page 126 you will see at a glance the exact work done by the engine and the cost of the same, the idea being to offer a uniform sheet so that comparisons could be made.

Mr. McCRUM—I will say, as a member of this committee, that it was the opinion of the members who were present that we would not be able to accomplish anything in this without conferring with the accounting department. What we might undertake to formulate might not meet their approval; so we put down what we believed to be approximately correct.

SECRETARY SINCLAIR—I move that the recommendations of this committee be made the recommendations of the association, and that they be indorsed by the association.

The motion was seconded.

Mr. J. DAVIS BARNETT—There is one clause I would call attention to, on cost of repairs: "But such expense should be kept separately and charged to the department responsible for the accident." If any railway officer tries to carry out that recommendation he will make for himself a most uncomfortable time. (Laughter.) He will have his hands full, from one end of the year to the other, quarreling with other departments, and personally I do not propose to vote for that particular recommendation.

THE PRESIDENT—I would say that my understanding of the recommendation of the committee in that respect is simply that in order to get a uniform performance sheet they want all these accidents kept off it. It is not necessary for us to quarrel with the transportation department, but simply when there is a wreck on the road for which the motive power department is not responsible, that they put that on their sheet and show it at the end of the year in their annual report or in some other way. I do not see any difficulty in handling the matter in that way. We do it on our line. Every accident that is caused by a misplaced switch we put on the performance sheet at the time, but we take care to make an explanation of it in another way.

Mr. BARNETT—I would ask the president if the annual report or semiannual report that his department makes to the president or to the Board of Directors does not agree with his performance sheet.

The PRESIDENT—Oh, it does.

Mr. BARNETT—That being the case, it seems to me that eventually the mechanical department has to carry the expense in the long run. That department had better make all its performance sheets and all its returns agree, and therefore that item of expense caused by accidents of other departments which will have to come in some shape or other on to the bal-

ance sheet of the locomotive department had better be included at once, so that all returns shall agree.

Mr. Smith—We make a weekly report to the general manager, showing all damages caused by accidents, misplaced switches and the like. At the same time it all comes on the performance sheets. This is a little private information for the general manager for his personal use. But, as Mr. Barnett says, I think this recommendation would mix things up pretty badly.

Mr. Robert Quayle—In listening to the report, it seemed to me that it would be a pretty difficult matter for us to have this performance sheet uniform. We can have it uniform, but when we come to compare one lot with another we will find at once that we cannot make proper comparisons. Having been connected with the Chicago & Northwestern Railway in Iowa, for six years in charge of two divisions there, I can say that nearly all of our trains, or a large percentage of them, were through freight, and consequently there was very little switching to be done. On the road with which I am now connected, I might state that 25 or 30 per cent. of the mileage is switching mileage. Consequently, while I am in full accord with the report here, yet if you make a comparison of the C. & N. W. and some of the other through trunk lines with some of the small roads on which the business originates and which have no through business, and consequently have to do all their own switching at junction points and at every station, it will not be a fair comparison. Therefore I say it is a pretty difficult matter for us to make a comparison, one road with another, and say that that man or that management is rather extravagant in the use of coal and other things.

Mr. Hill—You cannot make one suit of clothes fit all sized men, but the average man is five foot seven. Now, you cannot make a performance sheet that would be fair to all roads in the country; that is out of the question. But you can make one as near as you can get. Mr. Quayle's road would come in; that would increase his road some. It might not bring it up equal to the trunk lines, but that would be entirely impossible. As to Mr. Barnett's objection, I think perhaps he has some reason for that. But don't we do the same thing every day in car business.

Mr. McCrum—I do not know that that particular paragraph was designed to mean exactly what it reads. But it was put in there to convey the idea of separating the accounts so as to know what was due to engine failures, and to track failures and other things, and I think a good many of the roads do keep their accounts in that way now. I know we do. We keep an account of all the repairs due to accidents and state just what the accidents were.

Mr. Hill—It will be manifestly unfair for the performance sheet of one road on interchanging sheets to have charge of the accident repairs due to misplaced switches, etc. Some roads do it on separate sheets and some do not. The conclusion of the committee was that the great majority of roads keep this off their performance sheets in order to make a respectable show-

ing of the performance of the engine. It certainly ought to be kept off the performance sheet.

Mr. FORNEY—I have recently had a good deal of experience in making comparisons of the performance sheets of locomotives in this country and in Europe, and in going over the different sheets that have been sent to me, I find it very important, in order to make any sort of fair comparison, that there should be a division of the traffic, that is, that we should know all the expenses of the passenger trains and freight trains and switching trains separately. I do not observe in this tabulation here that such a division is contemplated.

Mr. HILL—It is all classified on page 4.

Mr. FORNEY—But the consumption of fuel and the other expenses are not divided. They go into a general statement in the lower form.

Mr. HILL—Each individual engine would show its service—passenger, or whatever it was.

Mr. FORNEY—Would there be a tabulated form dividing the passenger and freight service?

The PRESIDENT—I take it so.

Mr. FORNEY—I did not think from what was stated here that that was contemplated. Take such a road as the New York & New Haven, which has almost exclusively passenger traffic, it would be impossible to compare that with a road which has almost exclusively freight traffic unless such a division was made. That was a great difficulty I encountered in making comparisons of performance.

The PRESIDENT—It would have given a great deal more information if they had tabulated a regular performance sheet as they propose to have it appear.

Mr. C. F. THOMAS—As I understand that heading, it will make one complete line across the top of the performance sheet, and that when it comes to the first column—the engine number—that would be designated under the mileage of passenger and freight, and a summary of the expense would be run out and put up in columns under passenger or under freight.

Mr. McCRUM—That is the idea.

Mr. HILL—For instance, engine No. 10 was a passenger engine. There would be nothing in the freight column at all. It would show at once that it was a passenger engine.

Mr. FORNEY—Would there be a recapitulation there—summing it all up—showing what is done on passenger service and what is done on freight service?

Mr. HILL—That could be done, but we had to shorten this, because a good many roundhouses are not long enough to put the sheet up. This is about four feet long now.

Mr. FORNEY—In many of the reports which are made, notably on the Pennsylvania Road, they give a recapitulation at the end, collecting together all the passenger service and all the freight service and giving an

average. Now, that is an immense advantage in making the comparison of locomotives on different roads. I should think that would be a very grave omission if that was not included in any proposed publication of statistics. I would move you that the committee be requested to prepare some form of recapitulation of the performance of locomotives to be submitted to the association.

Mr. BRIGGS—I second that.

Mr. HILL—Do not the last two items satisfy Mr. Forney—average number of loaded cars per train? Does he want an average sheet for all of these?

Mr. FORNEY—I want the average number of cars in passenger trains and the average number of cars in freight trains.

Mr. HILL—The next to the last line provides for that, on the corner of the table.

Mr. FORNEY—That says "Average number of loaded cars per train." I am speaking now of a recapitulation in which you sum all up.

Mr. HILL—It is entirely customary now on all roads to sum up the passenger in one line and the freight in the other.

Mr. FORNEY—But I do not think that is provided for in this form.

Mr. MCCRUM—It is, with this exception—if the engine had a joint mileage, freight and passenger, it would go in, so many miles freight and so many miles passenger, and it would not be separated.

Mr. FORNEY—I am aware that this form gives the passenger mileage and freight mileage of each engine. But there should be a form in which the performance of all the engines is recapitulated, giving the average consumption of fuel per passenger mile and per freight mile. Such a table as that is of the utmost value in making comparisons. It also should be tabulated, giving the average number of cars in all passenger trains and the average number of cars in all freight trains. If they are separated it is almost impossible to make a comparison.

The PRESIDENT—You would wish a consolidation of all the passenger and freight engines and the average cast on them all.

Mr. FORNEY—An average cast on them all, under the head of switching, freight and passenger.

Mr. LAUDER—There are very few items in this report that I would make any objection to, but it seems to me, as long as we have got this matter now in hand and have a committee appointed, that they should also prepare and give us a form of exchange sheet. Now, these forms that are presented are well enough for certain purposes, but no one would like to have a form like that for an exchange sheet to mail all over the country, because no one cares what the number of the engine is, or what the name of the engineer is. I do not suppose the committee had that in view at all when this was prepared. With the exception of the objection that Mr. Barnett brings up, which I fully sympathize with, I see nothing to criticise, but it seems to me that this whole matter should be referred to the committee, with instructions—definite instructions to report next year, perhaps making some changes here—a form for an exchange performance sheet.

Mr. HILL—A postal card—is that what you want?

Mr. LAUDER—A postal card if thought advisable. Then we can see at a glance, if the accounts are all kept in the same way, just what the other man is doing. I see no reason why the allowance of mileage for switching engines should be increased from six miles to eight. Possibly the increased weight of switching engines used to-day over what they were when six miles an hour was used would justify an increase. But several experiments have been made, to my knowledge, in the last few years, and they never ran very long, because, instead of being six miles an hour, it was two or three, and careful observation has shown me that six miles an hour is a large mileage for the average switching engines as regards fuel. But when it comes to repairs, it is small. I believe that six miles an hour is about right, taking the total cost of running the engine. I think that in any of the published reports where the cost per mile and fuel and miles to the ton of coal are kept in the different classes of service, you will notice that switching engines get sixty to seventy and eighty thousand miles, and I have seen them get 120,000 to the ton of coal at sixty miles an hour—very likely small light switches doing very little work. That being the case, I should be rather inclined to criticise raising that to eight miles an hour. It might make our accounts look a little better to our general officers, but there is one fellow we do not want to deceive--namely, ourselves, and I should favor putting that back to six miles an hour, as it has been for twenty years. I should also be in favor of striking out that clause that Mr. Barnett mentioned. I think that will give us lots of trouble, and I do not think it really amounts to anything. The percentage of cost due to accidents is very small on all well-regulated roads, and we assume they are all well-regulated now. To undertake to make a separate item of that would cost us a great deal of trouble. It never occurred to me before that that should be made a separate item. Now, if my neighbors that I exchange performance sheets with are eliminating that item of cost, I have been behind all these years, and have been using a greater cost on the same basis than my neighbors. It seems to me that the motions now before the house had better be withdrawn and the whole thing remanded to this committee, with instructions to strike that out if it meets the members' views, and also with instructions to bring in a form for an exchange performance sheet with a recapitulation in a condensed form of the whole thing, so that all roads that choose to come into this can see at a glance, when they exchange, whether they are doing as well as their neighbors. I make that suggestion. I will not make any motion, because there is a motion before the house now.

Secretary SINCLAIR—I withdraw my motion with the consent of the seconder.

The PRESIDENT—I think that Mr. Forney's suggestion to make a recapitulation of the performance sheet for the purpose of exchange is a very fair one. I believe it is the only way to handle a performance sheet. But there are conditions connected with that which strike me as being very necessary, and one is a recapitulation of the classifications of engines. If

a railroad, for instance, is running consolidation engines entirely, showing in the recapitulation the cost per car mile, another railroad is running light engines or simple engines, 17 x 24 we will say, and showing the cost per mile, we have not anything in this recapitulation to show what the performance would be of those engines, unless you classify them. Now, in our performance sheet we make a classification of the engines; classifying them A, B, C, D, etc., showing the value of the large engine over the small one, or the other way, if it happens to be so; and it strikes me that, if that was borne in mind, if the committee was continued to give a recapitulation of the different classifications, it would meet Mr. Forney's idea, and it would be of some value to us, I think. It has been suggested to me by one of the members that there should also be a recapitulation showing the alignment of the road, whether it was a hilly road or a level road. That would make rather a cumbersome sheet, it seems to me.

Mr. FORNEY—I agree with what Mr. Lauder has said, that it would be of the utmost value if there was a division of the engines into classes, such as 4-coupled and 6-coupled and 8-coupled engines, on the performance sheet. I was afraid to suggest that for fear of getting the recapitulation too large. I may as well speak plainly: During the last year I have been engaged in making a comparison of English and American locomotives. I was making my observations under the eye of the most prominent engineering paper in England, and consequently it became me to be very careful about any statements I made. During this period I have been receiving locomotive reports from nearly all the railroads in the country. There are several difficulties I have encountered in doing that. In the first place, a small proportion of the roads divided the service into freight, passenger and switching. In the next place, a considerably smaller proportion give the car mileage. In the third place, only a few of them give the amount of coal consumed per car mile. Of course, if you know the average number of cars in a train and the number of miles run per ton of coal, you have the data from which you can figure up what you want. But if that was stated in a separate column showing the amount consumed per loaded car per mile, it would enable you to compare the service on different engines. If in addition to that the engines were divided, as suggested by the chairman, into four classes of 4-coupled, 6-coupled and 8-coupled, you could study the amount of coal consumed, and it would show the relative economy of these classes of engines and it would be of excellent service in studying the performances of locomotives.

If in printing the word "tons" in any of these performance sheets it was stated to be in tons of 2,000 pounds, it would prevent a great deal of ambiguity. You are never certain in making a comparison whether you are dealing with tons of 2,000 pounds or of 2,240 pounds. It would be so easy to add in brackets, "tons of 2,000 pounds," which would prevent that ambiguity.

I hope very much that it will be found practicable to carry out the suggestion of the chairman, because it would add greatly to the value of these reports.

The PRESIDENT—I think myself, Mr. Forney, that in making this recommendation to the committee we should have what is known as a master mechanic's classification provided for on the bottom of the sheet.

Mr. FORNEY—I should be afraid about going into that. It might be too cumbersome. The simple classification of 4-coupled, 6-coupled and 8-coupled perhaps would meet all the requirements of the present time. If we go into the other matter we might run into complications that I should be afraid of.

Mr. POMEROY—Instead of putting in "tons of 2,000 pounds," wouldn't it be better to say "net tons" and "gross tons"?

Mr. HILL—If you did that you would have people writing to you to ask what it meant.

Mr. FORNEY—I agree with you. I sometimes get confused about net tons and gross tons.

The PRESIDENT—I presume Mr. Forney refers particularly to hard and soft coal. I presume the hard coal is generally charged 2,240 pounds, while with soft coal the net ton is 2,000 pounds.

Mr. LAUDER—I would move that the committee be continued another year and that this matter be referred back to them with instructions to bring in a form of interchange performance sheet in addition to what they have this year reported.

Mr. FORNEY—I would like to make an amendment to that—that they also inquire into the practicability of publishing a profile of the road.

Mr. LAUDER—I will accept the amendment.

The motion was carried.

The convention then adjourned until the following day.

THIRD DAY.

The Convention was called to order at 9.20 A. M.

The President read a telegram from the President and Trustees of the Village of Waukesha, Wis., inviting the Association to hold its next convention at Waukesha; also a telegram from the Fountain Spring House, Waukesha; also a communication from J. C. Barber and J. N. Barr.

The Committee on Standard Bolts and Nuts submitted the following report, which was read by Mr. Pomeroy:

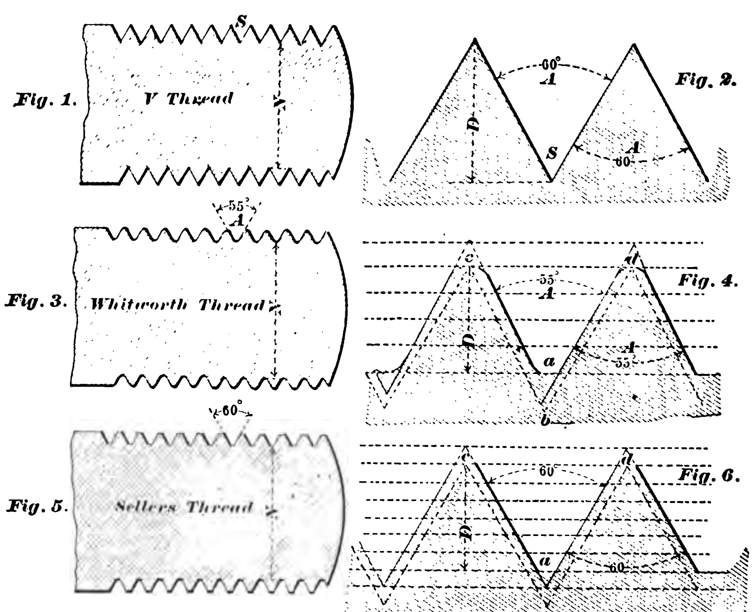
STANDARD BOLTS AND NUTS.

1. Standard size of nuts.
2. Standard size of bolt heads.
3. Standard size of taps for nuts.
4. Standard taper for locomotive fitted bolts.

At the third annual meeting of the Master Mechanics' Association, the Committee recommended the United States standard (Sellers) for bolts, nuts and screw threads; but in receiving the report the Association omitted to adopt the Committee's recommendation, and consequently the matter went over until the fifth annual meeting, at which time the United States standard was formally adopted as the standard for the Association. This being the fact, the duty of your Committee in the premises is a peculiar one, and its scope circumscribed and limited. On this account it was deemed best that the report should be of a more general character, mainly to urge upon all a rigorous observance and emphasis of the standard.

The Association not being on record as to the (*a*) origin and (*b*) claims of the United States standard (Sellers), your Committee deems it not out of place to give a brief synopsis of the system based upon (*a*) an essay read by William Sellers before the Franklin Institute, April 21, 1864; (*b*) the records of the meeting of the Franklin Institute, held December 15, 1864, and (*c*) the re-

port of the Committee of the Master Car Builders' Association, June, 1882, as sufficiently covering the subject. In 1864 the inconvenience and confusion resulting from the diversity in the screw threads used in machine and other construction was brought up for consideration before the Franklin Institute, Philadelphia, and the Committee appointed by the Institute carefully investigated and recommended the system designed by Mr. William Sellers, and the Institute afterward adopted their recommendation. Practically, the three systems from which they were obliged to choose were, first, the ordinary sharp "*V*" thread, shown in Figures 1 and 2. Fig. 1 represents a section of an inch bolt full size, and Fig. 2 a section of the thread enlarged eight times its actual size.



Figs. 3 and 4 show Whitworth's thread, and Figs. 5 and 6 Sellers' system. The angle *A* and *A'*, between the sides of the *V* thread is generally 60 degrees, although this is not uniformly so; when it is, the depth *D* from the root of the threads to the

point is slightly less than seven-eighths of the pitch. In the Whitworth thread the depth D is two-thirds of the pitch, and the top and bottom of the threads are then rounded, as shown. The angles AA', of the sides of the threads to each other are 55 degrees. The objections to the V thread are that the point or outer edge of the thread is sharp, and, therefore, very frail and liable to injury from contact with other objects. The space S, or groove, between the threads at the root is also sharp, which facilitates fracture under strain, and is a source of weakness in the screw. The depth D of the V thread being slightly greater than that of the Whitworth thread, the effective diameter N of the screw at the root of the thread is materially less in the former than in the latter.

The objections to the Whitworth thread are that the angle of 55 degrees cannot be measured or laid off with ordinary tools, and that the rounded corners at the point and root of the threads are extremely difficult to produce with any degree of precision in the tools required to make screws.

These considerations led Mr. Sellers to design the system of threads the form of which is shown by Figures 5 and 6. In this the angle of the V thread, 60 degrees, is retained, but instead of rounding the point and root these are made flat, one-eighth of the depth of the thread being taken off at the top and one-eighth at the bottom, which leaves the depth of the thread somewhat less than two-thirds of the pitch. This leaves the effective diameter N of the bolts somewhat greater even than that of the Whitworth thread.

The flat top and bottom in screw-making tools can be easily and accurately made, and the angle of the thread can be produced by simply laying off a triangle having equal sides, or subdividing the circumference of a circle with its own radius, and drawing lines from adjacent points of subdivision to the center. In a report made in 1868 to the Chief of the Bureau of Steam Engineering of the United States Navy by a Board of Engineers, the difference in the resistance to tension and torsion of bolts with Sellers threads, compared with those having V threads, was calculated, and may be approximately stated as follows: That the smaller bolts, with Sellers thread, have about a quarter more strength, the medium-sized ones a sixth more, and the larger ones

an eighth more strength to resist tension than screws having an ordinary *V* thread. Soon after its organization, the Master Mechanics' Association recommended the U. S. standard (Sellers) system of threads for general use in locomotive construction, and in 1871 the Master Car Builders recommended it for cars. Unfortunately, though, when this was done a large proportion of the members of the two associations seemed to have the impression that the U. S. standard (Sellers) system consists simply in a standard for the number of threads to the inch, and apparently not sufficient effort has been made to impress the fact on the minds of those who have the control of such matters that three features are essential to the Sellers system :

1. Screws must have a given number of threads per inch.
2. The threads must be of the form and proportions designed.
3. The diameters of the screws must conform to the sizes specified.

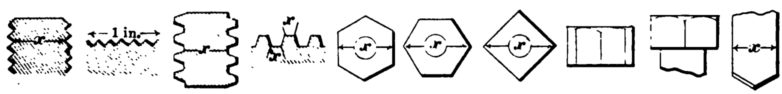
The Committee wishes to impress upon this Association that a specific diameter of screw is an essential feature of the United States (Sellers) system. A screw with a U. S. standard (Sellers) thread must be of one of the diameters given in the table. For example, the outside diameters of U. S. standard (Sellers) screws are $\frac{1}{4}$, $\frac{5}{16}$ $\frac{3}{8}$, $\frac{7}{16}$ $\frac{1}{2}$, $\frac{9}{16}$ $\frac{5}{8}$, $\frac{3}{4}$, $\frac{7}{8}$, 1, $1\frac{1}{8}$, $1\frac{1}{4}$ and upward.

There are no other sizes in the system except some larger than those given, not generally used in car and locomotive construction. There is no such thing, for example, as a Sellers screw $\frac{3}{4}$-and-$\frac{1}{32}$-inch in diameter. That size is not recognized and has no existence in the system, and if a screw is made, as is often done, $\frac{3}{4}$-inch in diameter, a sixty-fourth or a thirty-second large, it ceases to be a U. S. standard (Sellers) screw. Uniformity in diameter is as essential to interchangeability as uniformity in the number of threads per inch, or the shape of the threads, and the importance of maintaining the former cannot be too strongly urged on the Association.

The following table gives the results obtained by the use of these formulæ for all sizes of bolts. The only instance where the values in the table differ from those given in the formulæ is in the numbers of threads per inch, which are so far modified as to use the nearest convenient aliquot part of a unit, so as to avoid,

as far as practicable, troublesome complications in the gear of screw-cutting machines.

Standard Screws, Heads and Nuts.



Diameter of Screw.	Threads per inch.	Diameter at root of Thread.	Width of flat.	Short diameter of Hexagon or Square.	Long Diameter Hexagon.	Long Diameter Square.	Thickness Nuts.	Thickness Heads.	Tap Drill.
1/4	20	.185	.0062	1/2	37/64	7/10	1/4	1/4	3/16
5/16	18	.240	.0074	19/32	11/16	27/32	5/16	19/64	1/4
3/8	16	.294	.0078	11/16	51/64	63/64	3/8	11/32	5/16
7/16	14	.344	.0089	25/32	9/16	1 7/64	7/16	25/64	23/64
1/2	13	.400	.0096	7/8	1	1 15/64	1/2	7/16	13/32
9/16	12	.454	.0104	31/32	1 1/8	1 23/64	9/16	31/64	15/32
5/8	11	.507	.0113	1 1/16	1 7/32	1 1/2	5/8	17/32	17/32
3/4	10	.620	.0125	1 1/4	1 7/16	1 49/64	3/4	5/8	5/8
7/8	9	.731	.0138	1 7/16	1 21/32	2 1/32	7/8	23/32	3/4
1	8	.837	.0156	1 5/8	1 7/8	2 19/64	1	13/16	27/32
1 1/8	7	.940	.0178	1 13/16	2 3/32	2 9/16	1 1/8	29/32	31/32
1 1/4	7	1.065	.0178	2	2 5/16	2 53/64	1 1/4	1	1 3/32
1 3/8	6	1.160	.0208	2 3/16	2 17/32	3 3/32	1 3/8	1 3/32	1 3/16
1 1/2	6	1.284	.0208	2 3/8	2 3/4	3 23/64	1 1/2	1 3/16	1 9/32
1 5/8	5 1/2	1.389	.0227	2 9/16	2 31/32	3 5/8	1 5/8	1 9/32	1 13/32
1 3/4	5	1.491	.0250	2 3/4	3 3/16	3 57/64	1 3/4	1 3/8	1 1/2
1 7/8	5	1.616	.0250	2 15/16	3 13/32	4 5/32	1 7/8	1 15/32	1 5/8
2	4 1/2	1.712	.0277	3 1/8	3 5/8	4 27/64	2	1 9/16	1 3/4
2 1/4	4 1/2	1.962	.0277	3 1/2	4 1/16	4 61/64	2 1/4	1 3/4	1 31/32
2 1/2	4	2.176	.0312	3 7/8	4 1/2	5 31/64	2 1/2	1 15/16	2 3/16
2 3/4	4	2.426	.0312	4 1/4	4 29/32	6	2 3/4	2 1/8	2 7/16
3	3 1/2	2.629	.0357	4 5/8	5 3/8	6 17/32	3	2 5/16	2 5/8
3 1/4	3 1/2	2.879	.0357	5	5 13/16	7 1/16	3 1/4	2 1/2	2 29/32
3 1/2	3 1/4	3.100	.0384	5 3/8	6 7/64	7 39/64	3 1/2	2 11/16	3 1/32
3 3/4	3	3.317	.0413	5 3/4	6 21/32	8 1/8	3 3/4	2 7/8	3 11/32
4	3	3.567	.0413	6 1/8	7 3/32	8 41/64	4	3 1/16	3 19/32
4 1/4	2 7/8	3.798	.0435	6 1/2	7 9/16	9 3/16	4 1/4	3 1/4	3 13/16
4 1/2	2 3/4	4.028	.0454	6 7/8	7 31/32	9 3/4	4 1/2	3 7/16	4 1/32
4 3/4	2 5/8	4.256	.0476	7 1/4	8 13/32	10 1/4	4 3/4	3 5/8	4 9/32
5	2 1/2	4.480	.0500	7 5/8	8 27/32	10 49/64	5	3 13/16	4 1/2
5 1/4	2 1/2	4.730	.0500	8	9 9/32	11 23/64	5 1/4	4	4 3/4
5 1/2	2 3/8	4.953	.0526	8 3/8	9 23/32	11 7/8	5 1/2	4 3/16	4 31/32
5 3/4	2 3/8	5.203	.0526	8 3/4	10 5/32	12 3/8	5 3/4	4 3/8	5 7/32
6	2 1/4	5.423	.0555	9 1/8	10 19/32	12 15/16	6	4 9/16	5 7/16

The formula upon which the table is based is as follows, where :

D = nominal diameter of bolt ;
p = pitch of thread ;
n = number of threads per inch ;
H = depth of nut ;
d_n = short diameter of hexagonal or square nut ;
d = effective diameter of bolt = diameter under root of thread ;
s = depth of thread ;
h = depth of head ;
d_h = short diameter of head.

Then—

$$p = 0.24 \sqrt{D + 0.625} - 0.175$$
$$n = \frac{1}{p}$$
$$s = 0.65\ p$$
$$d = D - 2\ s = D - 1.3\ p$$
$$H = D$$
$$d_n = \tfrac{3}{2}\ D + \tfrac{1}{8}''$$
$$d_h = \tfrac{3}{2}\ D + \tfrac{1}{8}''$$
$$h = \tfrac{3}{4}\ D + \tfrac{1}{16} = \tfrac{1}{2}\ d_h$$

The form of the U. S. standard (Sellers) thread is such as to make it the most practicable for duplication to gauge, and by making the outside diameter slightly larger (not, however, larger than the angle of the thread) the life of the tap, or before it wears below gauge size, is greatly lengthened. The claim that the U. S. standard (Sellers) thread cannot be maintained in use seems inadmissible, for although the corners may wear slightly, the wear is unimportant if the taps are properly used, and especially so if made (as recommended) slightly larger in the outside diameter. In making taps and dies to conform to the U. S. (Sellers) standard, it is important that the diameter outside and at the root of the thread should be determined with sufficient precision to insure

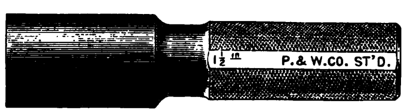


FIG. 7.

FIG. 8.

interchangeability. For this cylindrical size gauges, Figs. 7 and 8, are provided.

The first is a hardened steel cylinder plug, ground and lapped perfectly round and straight, and warranted not to vary more than 1-50,000 of an inch from true size. Fig. 8 is a ring which fits the cylindrical plug. Suitable caliper gauges for use in the shop are made and maintained to the correct size from the cylinder gauges. In the manufacture of taps, cylinder gauges are made for their outside diameters, and also for the diameters at the root of the threads. To test the taps and dies, and to insure their being near enough to the standard dimensions to produce bolts and nuts that are interchangeable, internal and external standard thread gauges are provided. See Figs. 9 and 10.

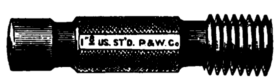


FIG. 9.

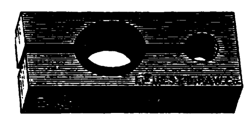


FIG. 10.

The internal gauge (Fig. 9) consists of a threaded cylinder made to exact size, and the external thread has a corresponding screw thread which is adjustable to the internal gauge. With a set of these gauges the nuts and bolts cut by any taps or dies can be tested at once, and it can be known whether they conform to the standard sizes ; also whether taps and dies bought of any firm are of the right size. This leaves the purchaser free to buy in the open market.

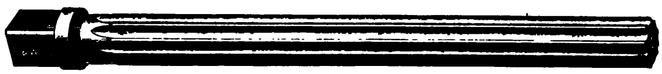
As the Master Mechanics' Association is on record as to limits of variation of diameters of round iron, and also as to limit gauges for testing same, it is not necessary to discuss this phase of the question.

Your Committee has met some questions relative to sizes for rough and for finished nuts, and wrote to Mr. Geo. M. Bond, of the Pratt & Whitney Company, asking his views on the subject. He very promptly replied as follows: "The matter of size for rough and for finished nuts, under the United States standard system, might be materially simplified by using both made to same dimensions ; that is, having the finished and rough nuts for same size bolt both fit the same wrench, which would necessitate that the blanks for finished nuts be made enough larger to allow for finishing to standard size. Heretofore, rough nuts were and

are the amount larger than finished nuts to allow for this finish, but this evidently requires two sizes of *wrenches even for nuts of the same size* bolt-threads. If a bolt is made perfectly straight and fitted into a reamed hole, it is an unsettled question as to how tight it should fit. In practice, the longer and larger the bolt, the nearer it is made to gauge size. A bolt so sized by gauge, as in a short length, to be a running fit, will seem very tight in a deeper hole. The difference between a tight and a loose fit is somewhere in the neighborhood of the ten-thousandth part of an inch. It is held by many locomotive builders that the use of straight bolts is objectionable, on the score that if they are driven in as tight as they say they should be, there is much difficulty in getting them out; that where they are taken out of a hole into which they have been driven two or three times, they become too loose, and there is no means of making them tighter, resulting in their being discarded. What system can we adopt that will enable workmen of limited capacity to do work that shall be commercially accurate? The taper bolt, for certain purposes, presents very decided advantages when considered in this relation." The large majority of bolts used on a locomotive, and made taper, can on the taper of 1-16 of an inch to the foot be driven home, if the size of the bolt and hole is such as will cause the head of the bolt to stand above the top of hole one-eighth of an inch, and when such bolt has been driven home it will have compressed the bolt or stretched the metal into which it has been driven to the amount of 0.0065 inch and the fit will be almost as tight as are car wheels forced on to their axle in the usual manner.

We beg leave to say in regard to the proper taper for taper-fitted bolts, the most practicable, and at the same time the most generally adopted amount of taper per foot, is 1-16 inch; that is, in one foot of length of bolt, measured under the head, the diameter at the end would be 1-16-inch less than that toward the head of the bolt. This taper allows for a tight-driving fit, at the same time permitting a ready removal in case of repairs being necessary, and also makes it entirely practicable to maintain standard uniformity, which, by the use of ordinary straight-fluted reamers, is impossible, by reason of the inevitable wear of the cutting edges of these reamers. The operation of re-grinding, or sharpening reamers, to get the best results, while reducing the diameter,

is obtained by allowing the reamer to enter slightly more, makes up this difference in size, as is evident to any one familiar with the practice of reaming. Thus a one-inch reamer should be one



inch in diameter at its small end. At one foot from its small end it should be 1 1-16 inches in diameter, and if beyond this, if it continues on the same taper, say three inches, it should measure 1 5-64 inches in diameter at its largest end. Such a reamer may be re-ground until its largest diameter has been reduced to the standard size. These reamers are guarded at their upper end by a collar driven on and covering the entire unused part of the reamer, which collar can be from time to time dressed off at the lower end to gauge, to keep the size correct. And this brings up the desirability of gauging in the best way the amount to allow a taper reamer to enter. One of the simplest methods is to use a steel template, or female gauge, hardened steel preferably, the hole of which accurately represents the diameter and taper per foot, the length varying from 2 to 4 inches according to the diameter of the bolt.

The latter, as now generally turned, with a taper attachment to an ordinary lathe, will be a reasonable fit the whole length, if this gauge fits along its length. The small end of the bolt should be turned to allow it to be just flush at this end, the threaded part, of course, outside.

These gauges for any single diameter, and for an average range of lengths, should be a separate template, not having a number of holes in one piece, especially if the template is to be hardened. The taper holes after hardening are to be ground true, so that this condition of distortion is provided for, and the gauges will last indefinitely.

To test the taper reamers an ordinary micrometer and a steel scale will cover the ground, but for more rapid inspection the use of two rather thin hardened taper templates, one to fit upon the small end and the other to be just enough larger to allow it to fit three inches, six inches or twelve inches above it, will quickly decide its true size and taper.

The duties of your Committee, as before mentioned, being of so general a character, no very particular recommendations can be made, and we will therefore close by

First, Commending and emphasizing the U. S. standard, and urge upon all a rigid adherence to same.

Second, That it is practicable to maintain the U. S. standard with the methods and gauges available.

Third, The Committee recommends the adoption by the Association of the U. S. standard for nuts, based on rough size, regardless of finished nuts.

The Committee wishes to acknowledge the valuable assistance received from Mr. Geo. M. Bond, of the Pratt & Whitney Company, and a paper by Mr. Coleman Sellers, with the sixteenth annual report of the Association.

WM. SWANSTON,
WM. GARSTANG,
T. W. GENTRY,
W. LAVERY,
A. DOLBEER,
L. R. POMEROY,
Committee.

On motion of Mr. Sprague the report was received.

DISCUSSION ON STANDARD NUTS AND BOLTS.

Mr. FORNEY—This is a subject in which I have felt a great deal of interest for many years, and have written, perhaps, as much upon it as would make a book as large as the New Testament. The battle still goes on, however. We seem at the present time to be departing from the standards which have been recommended, as in conversation with this and of the Master Car Builders' Association, I learn that the practice is again becoming very common of ordering over-size taps and dies of the manufacturers. A great many of the cars which are built now and which are coming into service are found to have screws which are over-size, and consequently when it is necessary to replace bolts it is absolutely essential to have over-size screws. Of course if this practice prevails and is continued it will be utterly impossible to establish any standard system of screw threads, and all the advantages of having a standard will be lost. Therefore, Mr. President, in order to get an expression of the opinion of this association, I should like to offer an amendment to the recommendation which has been made by the committee. The committee say: "First. That this association commends and emphasizes the United States standard and urges upon all a rigid adherence to the same." I would add to this, "and deprecates

the use of over or under-sized bolts and nuts, and urges all railroad officers to discontinue the use of screws which are not of standard size." I would offer this as an amendment to that first resolution.

The motion was seconded.

Mr. FORNEY—I move that the recommendations of the committee be adopted, and that the first be amended as I read it. I make that as a substitute for my first motion.

Secretary SINCLAIR—I second that.

The PRESIDENT—We understand from this report that it changes the standards of the association.

Mr. FORNEY—No, sir ; I do not understand it so.

The PRESIDENT—Not your motion, but the report of the committee. Does not the report of the committee change the standard of the association which was adopted.

Mr. FORNEY—I do not understand it so.

Mr. SWANSTON—No, it only makes an additional recommendation.

Mr. FORNEY—I understand the report reiterates the standard adopted before.

Secretary SINCLAIR—If I understand the matter rightly, Mr. President, the standard of the association calls for a larger size of rough nuts. That was adopted early after the Sellers recommendations came out, and was done by the Master Car Builders' Association so that the nut could be reduced to the finished size, and it calls for two sizes of wrenches for practically the same nut. The recommendation now is that we adopt the United States standard sizes of nuts so that the rough nut is the same as the finished nut.

Mr. FORNEY—I stand corrected by Mr. Sinclair. What I had reference to was the standard sizes of screws. There is no change in that, as I understand. The other matter I had not in my mind.

Mr. POMEROY—I do not know whether the association is on record as to the taper. I think that element is a new element—standard taper.

The PRESIDENT—The secretary says that the matter was discussed at the eighteenth convention, but no action was taken by the association. It is not a standard of the association.

Mr. MARSHALL—From the report of the 1891 convention the standard of the association seems to be in regard to the threads, and there is nothing given about the size of the nuts at all. The M. C. B. Association has adopted both, but from this report one would infer that the standard of this association related to threads only. Therefore this recommendation of the committee in regard to the sizes of the nuts and the heads of the bolts would be an addition to our standards.

Mr. H. N. SPRAGUE—I was going to say that I supposed from all the agitation there has been on this subject that we had got down to the United States standard, but I am surprised, in talking with nut manufacturers, to find that there are so many that are not using the United States standard thread. I cannot see the policy of it nor why people do it.

In reference to rough nuts and finished nuts, I would say that in my practice I do not use any finished nuts that are movable; they are all stationary nuts, and I do not care so much about a little variation in size. I select the best nuts and case-harden them rough. From the present standard of cold-punched nuts you can select nuts sufficiently accurate. That keeps the case-hardened nut the same as the rough nut, so that it requires the same wrench for both

The PRESIDENT—I think the members will bear in mind one thing that occurs to me, and that is that it is almost an impossibility to get rough iron so that you can use a ¾ nut on it. I think that was the cause of the sizes being added there.

Mr. FORNEY— I have been fighting this battle a good many years, and I hope, if I talk oftener than is good, that the gentlemen will excuse it and attribute it to my zeal in bringing about a reform. The difficulty the chairman speaks of was brought before the Car Builders' Association a number of years ago and discussed at a considerable length, and that association has adopted what are called limit-gauges for round iron. I do not know whether this association has ever adopted that as a standard or not. A member informs me that they have. Well, with the use of these limit-gauges, if the members could only be induced to inspect their iron as it is received and to refuse that which is over or under-size, there will be no difficulty about it. I know that a number of the members of the Master Car Builders' Association found considerable difficulty when the question came up. The manufacturers objected. As a matter of fact, if the manufacturers make iron over-size, they sell a good many more tons for a given order than they do if they sell it under size, and I think that is the secret of iron coming over-size to the extent to which it does. If members would use the limit gauges for iron and inspect every lot which is received, and refuse to receive it unless it comes within those limits, I think the difficulty our chairman speaks of would be entirely overcome. A number of our members told me that after they insisted on having the iron come of proper size there was no difficulty. They could get it.

Mr. DOLBEER—I am a little surprised in regard to these sizes of iron. We never have had any difficulty in the last five years relative to iron being over-size. Many of us remember when we used to get inch-iron and there would be difficulty in cutting a thread on that bolt; but in the last five, and, possibly, I might say, ten years, my experience is that when you buy inch-iron you get it an inch in diameter. I am inclined to think that there are manufacturers of round iron here who will bear me out in this statement. I am surprised at the question coming up in regard to the over-sizes of iron. I have not come in contact with it, perhaps, because we are fortunate in buying from somebody who maintains certain sizes. My experience is that the manufacturers of iron in this country are rolling 1-inch iron 1 inch. I would like to have the experience of other parties using iron to know whether they have encountered that difficulty during the last few years.

Mr. WILLIAM SWANSTON—I have been told that on quite a number of contract cars, there are bolts $\frac{1}{16}$ of an inch over-size and that certain tap-makers have been receiving orders for inch-taps and $\frac{7}{8}$-taps—$\frac{1}{16}$ of an inch over-size. To meet this, we understand that the manufacturers have collected quite a large quantity of iron that has been rejected by those that are particular, and they sell it to these car builders at a discount. They get their iron cheap. They get it cheap on account of it being discarded, and they are ordering taps from the manufacturers for the purpose of using up this iron. Now, all of that should be stopped.

Mr. SPRAGUE—I hope that the members will take full interest in this subject. It is a very important one, and if we could only settle it once and stick to our sizes we would eliminate a great deal of difficulty. When I was chairman of the Committee on Shop Tools and Machinery several years ago, I attempted to recommend the purchasing of all standard taps from standard makers, from the fact that it was difficult to make taps in railroad shops, on old machinery, that would duplicate. I wrote to Mr. Forney to inquire who the different tap and die manufacturers were. He told me I had better wait a few months. He said they had tried to come together on the subject, and found in the first place they would have to ascertain what the standard inch was. But they have overcome that difficulty largely, and I have found that the taps and dies and nuts of three of the large manufacturers interchange very readily.

Mr. FORNEY—What Mr. Sprague said is very true. In the beginning of this agitation on the subject of screw threads, Mr. Chanute, who had charge of the machinery department of the Erie Railway gave a large order for cars, and in doing so he was anxious to adopt a standard system of screw threads, and he went to the navy yard in Brooklyn and other places and got the gauges that were used to establish the standard, and he found that no two of the gauges agreed. The Platt & Whitney Company, who have shown a good deal of enterprise in this matter, undertook the manufacture of taps and dies, and the first difficulty they ran against was that they could not find a standard foot or yard on the correctness of which they were satisfied. They finally sent to London and got a copy of the standard yard, which is kept in one of the government offices in London. They got three duplicates of that, and then, at an expense of $25,000 they made a measuring machine with which they could sub-divide that yard with the utmost accuracy. They spent a large amount of money in getting up machinery for making taps and dies with the utmost accuracy. There are also other manufacturers who are making taps and dies correctly. Members need not fear that they will be unable to get taps and dies which are accurate. The difficulty comes in in the rolling mill. The rolling mills find that they sell more iron if they make it over-size. Their rolls wear and they find it more convenient to run along in that way, and unless the people who receive the iron inspect it and insist that it come in the proper size, they will continue this practice. Therefore, I think it would be an excellent plan if this association would have a circular prepared and issued to

all its members and to the managers of the railroads in the country calling attention to this fact. I will make a motion to that effect when this is disposed of.

Mr. SWANSTON—I presume that the thread business is fully understood. But I would like to call attention to the heads of bolts. I heard a great many of the members of this association and others say that they regarded the head of the bolt as too large. There is a disposition to use the turret machine and to use hexagon iron in the manufacture of tapered bolts; tight fitting bolts, and the large head makes the iron very expensive. There are a good many who think that the tapering of the size of the head from an inch bolt to the size of a ⅞ bolt would be amply sufficient. The committee have not recommended this. I only make the statement that such has been the opinion of a great many and that some are doing this. I want the opinion of the association on that subject. I simply call it up for that purpose.

Mr. E. S. MARSHALL, Madison Car Works—Referring to the question of the over-sizes of iron, at the beginning of the present year I went with a contract shop, and on going there I looked over the standards in the sizes. I found that we had specifications from three prominent railroads. The specifications called for United States standards. I also found that it is customary for those railroads to send the samples of the bolts that they require to go into those cars. I was very much surprised to find that all of the samples were over-sized and were not in conformity with the specifications. Therefore, I do not think that you are in the proper line when you condemn the contractors for doing what they are asked to do. In pursuing my inquiry in this line I called the attention of the inspector of one of our very largest systems of railroads to the matter and asked him if they meant what they said in the specification, as our standard was the United States. He said: "We want them patterned after those we sent,' which were $\frac{1}{16}$-inch over-size.

Mr. FORNEY—Mr. President, the motion that is made is that the recommendations of the committee be adopted and that they be amended as I shall read them:

First, That this association commends and emphasizes the United States standard and urges upon all a rigid adherence to the same, and deprecates the use of over or under-sized bolts and nuts, and urges all railroad officers to discontinue the use of screws which are not of standard size.

Second, That it is practicable to maintain the United States standard with the methods and gauges available.

Third, The committee recommends the adoption by the association of the United States standard for nuts based on rough size regardless of finished nuts.

Fourth, That the committee be instructed to prepare a circular calling attention to the importance of maintaining the standards of screw threads, and that the secretary send copies of this circular to all members, general superintendents and general managers and railroad newspapers.

The motion was carried.

The Committee on Boilers for High-Pressure Locomotives submitted the following report, which was read by the secretary:

BOILERS FOR HIGH-PRESSURE LOCOMOTIVES.

Your Committee on "Boilers for High-Pressure Locomotives" concluded, as the number of roads using high-pressure steam on their locomotive boilers was limited, to request the information regarding boilers of this class (the Belpaire included), direct from the (motive power) officers of these roads, in preference to the usual method by circular. The following gentlemen have complied with our request:

Mr. F. W. Dean, mechanical engineer, writes: "The Old Colony compound locomotive carries 195 to 200 pounds of steam and has been running every day since November 4, 1891, making thirteen weeks of continuous service. We do not see any reason to suppose that it is going to be troublesome as to its boiler. There is no evidence that the boiler has a heavy pressure except by the indication of the steam gauge. Personally, I should never think of using any boiler but the "Belpaire" for high (or low) pressure, but few people feel as strongly on this point as I do. I have designed 90 in. stationary Belpaire boilers for 185 pounds of steam, which have given no trouble that I have heard of."

Mr. Wm. Garstang, superintendent of motive power, Chesapeake & Ohio Railway Company, writes: "I wish to call your attention to blue prints of two types of boilers used on this road, carrying a maximum pressure of 165 pounds per square inch. The wagon-top boiler is used in a number of 19 in. x 24 in. cylinder 8-wheel passenger engines, also in quite a number of 19 in. x 24 in. cylinder 10-wheel freight engines. The Belpaire boiler is used in 21 in. x 24 in. cylinder consolidation engines.

"So far as the boilers themselves are concerned, I have not experienced any objectionable features, or increased repairs to same on account of high pressure, but have, however, noticed that the cylinders and steam-pipes work loose more frequently on these engines than on engines carrying 140 pounds pressure and less. Have also noticed that driving-boxes, main and parallel rod-bearings, wear more rapidly. In fact, I believe all working parts

do, more or less, but cannot say to what extent, as we have not kept an itemized account of same.

"We have thirty-four locomotives with Belpaire boilers, same as shown on blue print. I have yet to receive the first complaint about any of these boilers carrying water badly, while on the other hand, a great many of our engineers prefer them to the wagon-top boiler in that respect, and all agree that they steam much more freely."

H. J. Small, superintendent of motive power and machinery, Southern Pacific Company, writes: "The only engines we have carrying high pressure (that is, 180 pounds boiler pressure) were recently received from the Schenectady Locomotive Works. We have not yet made drawings of the boilers. The engines referred to are compound, and for this class of engine I consider that there is no question but that high-pressure steam is beneficial. Have had no experience with the Belpaire boiler. Would say, no objectionable features have developed in the use of high-pressure steam in the engines above referred to."

Mr. C. E. Smart, general master mechanic of Michigan Central Railroad Co., writes: "I am not in a position to give you much information or an opinion of much value on the subject, as we have but two engines in service that are carrying 180 pounds pressure, but have quite a number of 10-wheelers that are carrying 165 pounds.

"As regards any objectionable features that have developed from increased pressure, or as to whether increased pressure has necessitated increased repairs, I can only say, that so far, we have experienced no particular difficulty, but we have not been using the high-pressure long enough to have developed any particular defects, and for that reason I do not feel that the information that I have to give would be particularly valuable on this point.

"As to the merits of the Belpaire boiler for carrying high pressure, I should not wish to express an opinion for the reason that I have had no experience with that type of boiler, but I feel free to say that I am not very favorably impressed with this type of boiler as having any great advantage over the ordinary form of boiler with crown-bars or with radial-stays.

"As regards the construction of boilers for extreme high pressure, there are different ideas among men as to the form and

construction of joint for longitudinal seam, and I believe that it is considered the butt joint, with inside and outside welt strips, to be preferable to lap joint with inside welt-strip, and it is my opinion that in extreme high pressure the butt joint would be preferable. I believe there is a great advantage in double riveting the mud-rings, as in boilers so constructed we have had less trouble with leaks at mud-ring than the single riveted mud-ring, with which it is very difficult to keep mud-ring tight, especially at corners. Another advantage with double riveted mud-ring: if there is any pressure tending to force the inner firebox down, the double riveting is certainly of great advantage."

Mr. J. H. McConnell, superintendent of motive power and machinery, Union Pacific system, writes: "Am much interested in this subject as we are now preparing to build some boilers to carry 180 pounds of steam. Have given the matter considerable thought and would very much like the views of other people on this subject. We have a 10-wheel engine boiler now under construction, 64-in. shell, 8-ft. firebox with radial stays, using $\frac{9}{16}$-in. steel for shell, $\frac{5}{8}$-in. throat-sheet with 280 2-in. flues. Have also a boiler under construction for an 8-wheel engine, 60-in. shell, 250 2-in. flues, $\frac{9}{16}$-in. steel in boiler throughout, with radial stays. Would prefer iron for boilers throughout, provided it could be obtained of as good quality as steel, but, as the iron manufactured now is liable to blister and the sheets split, think steel is the best material."

Mr. A. B. Underhill, superintendent of motive power, Boston & Albany, writes: "We built our first high-pressure boiler in 1880 and since that year have built 118 of them. We built them the same form and design as the low-pressure, but stronger; plates thicker and more strongly stayed. They have given us perfect satisfaction, there being no more repairs or failures than formerly. We carry 160 lbs. pressure on them. Have had no experience with the Belpaire boiler."

Mr. W. H. Thomas, superintendent of motive power, East Tennessee, Virginia & Georgia Railway, writes: "We have three of the high-pressure boilers in service. These are of the radial-stay wagon-top type carrying a pressure of 180 pounds, and tested to 200 pounds. These boilers have been in service one and a half years, and so far have not failed in any particular. Our re-

stays. I claim that the tendency to break these upper stay-bolts is increased, over and above the direct pressure as between these two sheets in the water-space, in direct ratio with the strain on the side-sheets acting to straighten the outside sheet.

"I have seen a good many radial-stayed boilers that were continually breaking the upper row of stay-bolts, and that had pulled out the radial stays near the sides. In my opinion this was caused by the fact that they not only had to withstand direct pressure of steam, but also the strain that would be put on, we will say a ½-inch square bar of iron bent to the form of the outside shell. If pressure representing the boiler tension was applied to this bar and at the same time it was pulled from each end, the forces would have a tendency to straighten it at the concave point looking from the outside.

"Another thing; it is nearly, if not quite, impossible to put heads on the inside of crown-sheet on the two or three outside rows of crown-stays, and I do not consider any crown-sheet securely stayed unless it has such heads, so that in case the sheet stretches or buckles in any way so as to draw the hole to a size larger than originally threaded, the tendency to pull out will be resisted by something besides threads or slight riveting, as most of them are.

"My idea of a boiler is the Belpaire type, braced at the corners in such a manner as to prevent any tendency to assume a circular form over the water-space in front of the firebox and to relieve forward row of crown-bolts of any excessive strain due to the unstayed part at that point. It should also have sufficient T or angle-irons across roof-sheet to prevent the tendency in the same way to assume a cylindrical form in case crown-sheet should become overheated. The crown-bolts passing directly through the inside sheet without thread, and either screwed into and through roof-sheet, or passing through it without thread to have nut on top, but to have spacing thimble between roof and crown-sheet, so that they can be drawn securely and solidly against the head under crown-sheet and against this thimble, in which form we would receive the full benefit of the direct stays between the two parallel sheets of crown and roof-sheet, both of them being sloped the same, say three inches in twelve feet. In case one of these crown-bolts should break, the danger would be

discovered at once by leakage in the firebox and before enough of them had become broken to render the boiler dangerous. With the present general form of construction of the Belpaire boiler, no one knows when a crown-bolt breaks until others surrounding it give way and let the sheet bulge. This is the case in either the radial-stayed boiler or the Belpaire, and most assuredly no one will advocate the desirability of the thread through crown-sheet, except to save the cost of the thimbles. Perhaps it would be well to screw through roof-sheet so that if a bolt breaks there would be no danger of steam enough escaping through the top to injure anyone, as might possibly be the case if it passed directly through both sheets. This danger would be almost nil, as the thimble would protect the hole from any great escape of steam, while it would not protect the lower end enough, but that it would indicate by leakage that the bolt was broken."

Mr. Reuben Wells, superintendent of the Rogers Locomotive and Machine Works, writes: "We have built fourteen engines for the Chesapeake & Ohio Railroad Company about eighteen months or two years ago, all to carry 170 pounds working pressure. Ten were consolidation engines 21 in. x 24 in. cylinders, boilers 62 in. diameter at smoke-box and were of the Belpaire type, Fig. 1. Four engines were 10-wheel passenger 20 in. x 24 in. cylinders, boilers 62 in. diameter at smoke-box. These were radial-stay boilers, wagon-top raised 6 in., back end and connection ring were a true circle. We built five 10-wheel passenger engines this size and type of boiler for the Louisville & Nashville Railroad Company some twelve months ago, which also carry 170 pounds pressure. Last fall we built twenty-two consolidation engines with Belpaire boilers 62 in. diameter at smoke-box to carry 170 pounds working pressure. For the Illinois Central, we built one pusher—consolidation engine—for the Nashville, Chattanooga & St. Louis, 22 in. x 24 in. cylinders, 66 in. diameter of boiler at smoke-box, Belpaire type, to carry 170 pounds working pressure. We have also built wagon-top boilers to carry 175 pounds working pressure, some lately, for the New York & New England Railroad, etc.

"For several years past 160 pounds was the usual pressure specified by our customers, but lately the figures have been higher by some roads—up to 180 pounds, as stated. My opinion is, for large boilers, say over 60 in. diameter at smoke-box, the Belpaire type,

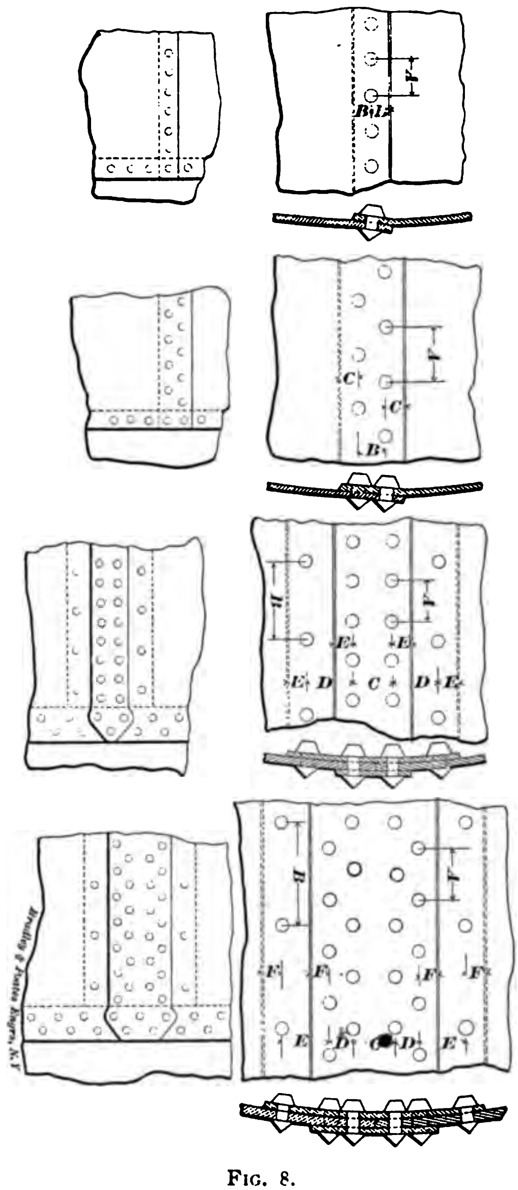


FIG. 8.

RIVETING.

Horizontal seams quadruple, riveting ⅞ in., rivets 4½ in. pitch. The same style of riveting at the juncture of throat and connection sheets. Double riveting on first vertical seam and the same for the second vertical seam, firebox and waist ⅞-inch rivets, 2¾ in. pitch. Double riveting at bottom flange of dome and a single row on the re-enforcing flange ⅞ in. rivets 2¾ in. pitch. Mud-ring double riveted ⅞ in. rivets 2¾ in. pitch.

Thickness of Sheets.

Front flue sheet,	½	inch.	Dome sheet,	½	inch.
Barrel "	½	"	Crown firebox "	⅜	"
Connection "	$\frac{9}{16}$	"	Flue "	½	"
Wagon-top "	$\frac{9}{16}$	"	Door "	$\frac{5}{16}$	"
Sides of firebox	$\frac{9}{16}$	"	Side "	$\frac{5}{16}$	"
Back head sheet,	½	"			

The Schenectady Locomotive Works furnished two blue prints; one radial-stayed boiler with extension wagon-top, Fig. 4, now on Michigan Central Railway, No. 338, a ten-wheel compound passenger on fast trains from St. Thomas to Windsor. The print, Figure 5, for 19 in. x 24 in. cylinder passenger, is for N. Y. C. & H. R. R. R. fast passenger service. These boilers are running the "Empire State Express" carrying 180 lbs. pressure.

The Rhode Island Locomotive Works furnished a blue print of a 56 in. wagon-top boiler, Figure 6, designed to carry 180 lbs. pressure. The only change they make is, to arch the crown-sheet about 1½-in.

The Pittsburgh Locomotive Works furnished blue print of boiler, Figure 7, designed to carry 180 lbs. pressure. Also blue print of method of making butt joints, Figure 8. The factor of safety in this boiler is 4.8, and joint used is one shown at right upper corner of print and has six rows of rivets. The flanged sheet T braces, riveted to back-head and front flue-sheet, are calculated to be strong enough as a beam, to carry the load upon them when supported by the top flange and the braces at the bottom. The braces are shown in Figure 9, and are peculiar, being Mr. Wightman's design and patented by him.

The Baldwin Locomotive Works furnished a white print of one of their standard type of boilers for carrying 200 lbs. to the square inch. Figure 10.

We have also a blue print of a boiler of the Belpaire type, built by the Pennsylvania Railroad, for their class "O" engines, designed to carry 175 pound pressure, Figure 11. They are now building almost exclusively the Belpaire type of boiler and claim it is the best design, that the plan of staying flat surfaces to each other is the true one and gives the best results. The design of the other boilers used by this company is similar to this one. The outside shell-sheets are the same thickness as the firebox This

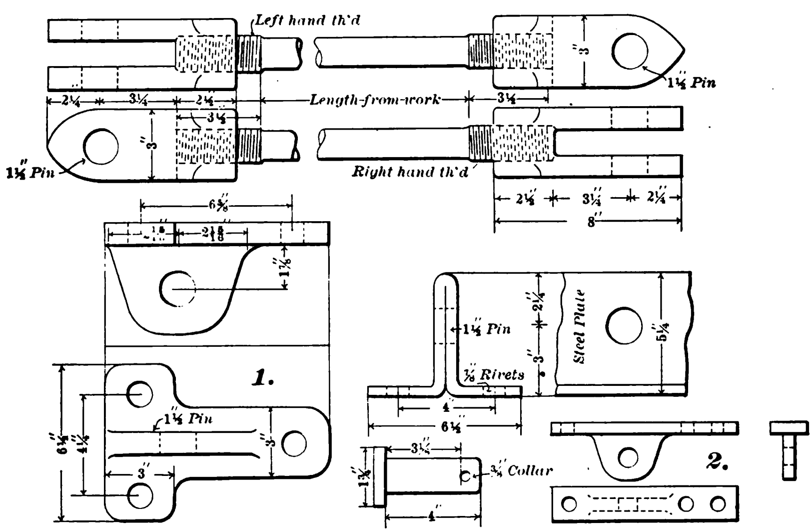


FIG. 9.

is a departure from the usual practice. The idea is to make both sheets of equal flexibility so that the strains due to vertical expansion of the firebox sheets will not be concentrated next to the outside sheets, which is the case when this sheet is thicker and consequently stiffer. The stay-bolts at top of firebox are longer than in general practice. The departure is a good one, the increased length reducing the tendency to break. It will be noticed that the crown stays project through the sheets and have nuts on them. The two front and two back rows of crown stay-bolts are made flexible by nuts and ball joints. This arrangement is to relieve the strain and tendency to buckle these rows of bolts.

merits will soon be understood and appreciated. The Belpaire boiler costs about $150 more to manufacture than the ordinary boiler. The objections to the boiler, with crown-bars and sling-stays for high pressure, have been fully described by Mr. Wells. The butt-joint has been generally accepted as the best, though the covering-plates make a resistance to the boiler retaining true circular-shape in expansion. The ideal-boiler is one without joints, but as we cannot have that, we should have as few joints as possible. Waist or cylinder-part of boiler should always be made in one sheet. Outside shell of firebox could also be one, and when radial stays are used inside-sheet could be a single one. The blue prints accompanying report show the most advanced construction of the different types of boilers for high-pressure steam and are worthy of close study. The locomotive builders furnish designs as called for by their patrons. The thanks of your Committee are due the locomotive builders for prints and courteous offers of assistance in this work.

JAS. M. BOON,
H. D. GORDON,
J. S. GRAHAM,
J. H. MCCONNELL,
Committee.

On motion of Mr. Briggs the report was accepted.

MR. H. D. GORDON—The subject put before the committee was somewhat ambiguous. We did not know exactly how to take hold of it, but the committee thought that by getting the best practice of to-day, in regard to high-pressure boilers, they would be doing about all that they could do. It is only quite recently that it has been the practice to carry excessively high pressure—in fact, only since compounding has come into vogue. There is one thing which seems to be pretty well settled, and that is that in building a boiler for high-pressure steam, the old crown-bar type has about gone out of use and the radial-stay type and the Belpaire type seem to be the most in favor. Both have their advocates. Both are good. The point has been raised that with a radial-stay boiler, the stays are not going through the sheets in the right angles, as good threads cannot be had, and therefore, that was a point against us. But that does not seem to have been sustained. There are hundreds of radial-stay boilers in service to-day that are doing well and giving no trouble. The Belpaire type has a great many advocates, principally from the fact that the flat surfaces can be stayed directly to each other, which is very good. Perhaps the most troublesome thing about a boiler for an exceedingly high pressure is the matter of

of view, that stay-bolts of this shape should give a greater number of vibrations before breaking than stay-bolts of the ordinary form, other conditions being equal.

Mr. Pulaski Leeds—I would like to call attention to the proposition I make in this report as to the construction of a boiler of the Belpaire type. It is on page 6. I have boilers built in that way and I consider them about as near perfect as they can be made. I would say that the nuts on top of the roof sheet are made at least 1½ times the thickness of the bolt, so that I can use a fine thread and still get the strength needed.

The President—I would ask if any of the members have observed the practice of turning the thread off between the sheet and stay-bolt.

Mr. Leeds—I am very sorry Mr. Meehan is not here, for he has been practicing that for the last two or three years and claims extraordinary results from it. He turns the bolt to about $\frac{1}{32}$ below the diameter at the thread and almost the entire space between the two sheets.

The President—I think some two or three months ago, in conversation with me, he said he had entirely obviated the broken stay-bolts by that practice. He simply turns out the part bolt between the two sheets, as near as practicable, so that he gets the spring in the center of the bolt instead of near the sheet.

Mr. Swanston—Our practice in the matter is to have a headed bolt, something like an old crown-bar bolt. We turn off between before we cut the thread. We do it in a lathe and use a lathe that has the same pitch, so that we can cut the thread with an ordinary screw machine head on the lathe—cut the point and slip it up and cut the head without the trouble of this expansion, which comes into the bolt by getting a long bolt and making a variation. By that practice we get the exact pitch. We make two taps and fit a solid connection between the two and put it right in and tap it up. Then we take out the connection and take the pieces out and put together again. In that way we get a tap that is exactly correct and we also avoid the trouble from the expansion of the bolt in cutting a long bolt.

Mr. Leeds—In reference to Mr. Meehan's practice, I wish to say that with these stay-bolts on the side of his firebox that he turns out in this way, I have found excellent results in the long radial stays in swedging them down between the screw threads and then cutting them in the usual way. But I have a master tap to which I draw these bolts cold. I find that the variation is so slight that with a top and bottom swedge a few taps of the hammer will lengthen them to come to the master tap. Of course in the stays across the boiler above the crown sheet, they being so long, we can really get a better job in that way than we can in cutting it in the lathe and we are pretty sure that they are right. Of course with the headed crown bolts we cut under the head with the lathe and at the other with the bolt-cutter. I never cut a thread in the lathe that I can cut in the bolt-cutter.

The President—Has Mr. Mitchell, of the New York, Lake Erie & Western, anything to say on this subject?

Mr. A. E. Mitchell—All I have to say is that we are getting very good

satisfaction, indeed, with our radial stay-bolts. We think they are first-class.

The PRESIDENT--I would call on Mr. Smart, of the Michigan Central.

Mr. C. E. SMART—Mr. Chairman, I think the ground has been pretty well covered. But I would say for the last two or three months we have been having considerable trouble with broken stay-bolts, and within the last two or three weeks it has occurred to me that in putting in the stay-bolts, instead of turning them down, it would be better if we were to flatten them. It is a well-known fact that the stay-bolts spring at the outer sheet on account of the leverage that the box has, and the strain is concentrated at the outer sheet. Now, if a stay-bolt can be made by swedging down flat and distributing the strain over that three or four inches, as the case may be, according to the space—if you can distribute that strain over the entire length of the bolt between the two sheets, instead of concentrating it on the outer sheet, it seems to me that it will be an improvement and will show good horse-sense, as much as in making a bolt to distribute the strain over the entire length of it instead of concentrating the strain at the center. I have thought of that, and I intend to try it. I presume that there are very few men here but what have found at some times in boilers fifteen or twenty stay-bolts that have been broken, and it is sometimes wondered how the boiler holds together. At least, that has been our experience, and we have found at times 15, 20 or 25 stay-bolts broken, and perhaps those stay-bolts have not been in to exceed eight or ten months. We examine the boilers every time they come into the shop and test the stay-bolts thoroughly. We do that by means of holding on, on the inside, and striking the hammer on the outside, and do that with the boiler under steam, so as to throw the bolts apart in case they are broken. I merely make that suggestion in regard to the flattening of the bolts.

Mr. J. N. LAUDER—I think the discussion of this question should be very full and all information given that any one possesses, because we are arriving at a time when we shall probably use very high pressures. I have used for eight years pressures ranging from 170 to 190 pounds, and careful designing, good workmanship and good material must be used to stand these enormous pressures. I think it is generally understood that the fewer longitudinal seams we can have to contend with in a boiler the better. Take the old well-known type of boiler, that circular outside crown and inside crown set with crown bars, which I used. I have got the number of longitudinal seams down to a minimum. The waist of the boiler is in one sheet, with a butt joint, a joint that gives between 91 and 92 per cent. of the strength of the solid plate. Then the outside crown runs from one mud-ring over to the other mud-ring on one sheet. In the wagon-top style of boiler the connection sheet is made in one shape. It may be thought that this is a difficult sheet to fit on, on account of its shape. It is generally considered so by the boiler makers, but after a little practice it is found to be a very easy job to do and a cheaper job than to put them on in the old-fashioned way with a seam at each side.

The point that the committee makes in the riveting of the mud-ring is a good one. With these high pressures and enormous strains we must have a good foundation. I agree with them that mud-rings ought always to be double riveted.

Now, this question of screw stays on the side of the firebox seems to be the worst one to contend with in carrying high pressures. Personally I have had no difficulty whatever in that direction; but you must all remember that we have good water and that removes a great many of the difficulties that are usually found in the maintenance of boilers carrying high pressures. I believe that we should use a little larger stay-bolt than is the ordinary practice. I think there are locomotive builders that are to-day using ⅞-inch iron for the short screw stays on the sides of the boilers and those boilers carry pressures upward of 150 pounds. My observation is that these stays will soon break and need to be very carefully looked after to make the boiler safe. My own practice is to use inch stays and of the very best material that we can buy. In fact we pay 6½ cents a pound for our stay-bolt iron. Out of a lot of about fifty boilers that are carrying 170 pounds of steam, the oldést of them having reached upward of seven years, we have so far had but two broken stay-bolts. Now, this may be attributed to the size and length, and the kind of iron, but probably mainly to the kind of water, as I do not think any iron would stand that length of time on some of our Western roads. But with us it does stand. How long they will run without breaking, I am unable to say. I think the committee's suggestion in regard to narrowing the top of the furnace—I am now speaking of the old wagon-top boiler—is a very good one, as a little more distance for water space in the top of the furnace is a good thing to have in every sense. It gives you a good circulation of the water. It is not detrimental to the steaming of the engine, as I believe most of our boilers are over-flued, and it gives us a longer stay-bolt, which is much more durable than a shorter one.

It is not necessary to enter into the question of material in the boiler, because that has been thoroughly discussed. I think we should put in heavier plate, as a rule, than what we are now using. Our boilers are ½-inch with butt joints. But in the future I shall use $\frac{9}{16}$ steel plates and intend to get the best that are made. That gives, with any reasonable size of boiler, I think, ample strength—perhaps up to 56 inches in diameter. If the boiler is larger than that, possibly ⅝ plate should be used for the outside shell.

Mr. Leeds—I do not want to assume any of the prerogatives of the president or to forestall him in any way. Therefore I will explain why I now ask him to call on Mr. Vauclain. Mr. Vauclain told me the theory upon which he bases the use of the iron that he uses for stay-bolts, and some facts that have come to my knowledge bear out his theory in every respect, and I think it would interest the convention to hear from him.

Mr. Vauclain—Mr. Leeds has kindly asked me to state my experience in regard to stay-bolt iron. Stay-bolt iron with us is a question of some

importance. We manufacture every year in the neighborhood of a thousand boilers, all the way from an ordinary soup kettle up to boilers 76 inches in diameter. We build about 90 per cent. of those boilers with radial stays or square-stay boilers of the same sort. A crown-bar boiler is the exception. In crown-bar boilers we have to contend with the side stays.

While listening to the conversation here in regard to the methods of putting in stay-bolts, I was surprised to hear that some of the members talked about experimenting with turning stay-bolts down between plates. That has been our ordinary practice. We do it in all cases with the exception of very short bolts located in places where they have never been known to break. I think it would be well to turn down all stay-bolts between centers. It is done just as cheaply as turning a stay-bolt and cutting a thread on it all the way across. If one boy can handle a machine that will cut eight stay-bolts at one time, I do not see why any one should question the expense of doing the work. You can pursue any method you please to make the bolt, but if you do not use the proper material it will be of no use. Take steel that is high in tensile strength—that will stand more vibratory action than steel of low grade. Take pistons made of steel of 55,000 pounds tensile strength and I will guarantee that you will not have one-fourth the life of them as if made of 80,000 pounds tensile strength—provided you have the proper elongation. So it is with stay-bolts. The inclination of a good many people is to get stay-bolts as soft as possible. I do not believe in that at all. What I believe in for stay-bolt iron is an iron as hard as you can get it. You want a good, clean iron of good fiber. But you want it as hard as that iron can be made to allow you to head them up nicely. Iron of that kind will stand a great deal more vibratory action on the boiler than when it is so very soft that you can hammer it up and squeeze it up like putty. We use iron having a tensile strength of 50,000 to 52,000 pounds, with an elongation of 30 to 35 per cent. in a 2-inch section; from 20 to 25 per cent elongation in an 8-inch section. We do not care about a stay-bolt iron that will run below 52,000, and we do not care about 35, 38 or 40 per cent. elongation.

I would like to say a few words on some other matters. In regard to the thickness of plates and the thickness of stay-bolts in high-pressure boilers. I think that the thickness of plate in a high-pressure boiler should depend on the diameter of the boiler and the amount of steam-pressure you wish to carry. Anyone about to construct a boiler should consider what factor of safety he desires, and proportion his sheets accordingly. If he is going to build a boiler 56 inches in diameter he does not want a ½-inch plate. In the diameter of his stay-bolts he should consider the load he will have to carry and he should make it of a diameter to carry that load within a given factor of safety. If this course is pursued I do not believe you will have any trouble with stay-bolts in radial-stay boilers.

Mr. William Smith—I would like to ask Mr. Vauclain whether he increases the size of his stay-bolts in his high-pressure boilers or not, and whether he decreases the space between the bolts?

Mr. VAUCLAIN—We do. We not only increase the size of the stay-bolt iron, but we also decrease the space between the bolts. In a locomotive boiler the thinner you get the firebox plates the longer life you can get out of those plates. The thickness of the outside shell simply depends on the pressure you can carry, but the inside sheets we like to get down to the minimum. For that reason we use a $\frac{5}{16}$ plate for all firebox plate. I do not know but a quarter of an inch would be better, but that would necessitate placing the stay-bolts slightly closer, provided you want to keep the high factor of safety that we adhere to and that is the factor of safety of five.

Mr. SWANSTON—I would like to ask why increase the diameter of the stay-bolts, if there is space for a $\frac{5}{16}$ sheet in proportion to the pressure carried?

Mr. VAUCLAIN—Mr. Swanston puts the question in nearly the same shape, but uses other words. If we reduced the space between the bolts entirely in proportion to the pressure carried we would get those staybolts perhaps too close for service. These stay-bolts would be so close together that the boilers would clog up with mud. As we increase the size of the bolt we simply keep our stay-bolts sufficiently far apart to keep the sheets from bulging. In the other case, with a lower pressure, we can go farther apart and keep the plate from bulging and still carry the strain in these plates with a lighter bolt.

Mr. REUBEN WELLS—I have just come in and I do not know exactly what has been under discussion except that you are talking of the matter of the tensile strength of iron best adapted to stay-bolts, and as I have had no practical experience with stay-bolts for some six or eight years, I am not prepared to discuss that question very intelligently. I think this, however, the diameter of stay-bolts should be proportioned somewhat to the thickness of the sheet through which they pass; that is to say a $\frac{7}{8}$ bolt will break sooner when it is put through a $\frac{1}{2}$-inch sheet than when it is put through a $\frac{3}{8}$-inch sheet, for the reason that the thicker sheet is so stiff that the bolt itself must spring when the expansion of the inside sheet forces it out of its original position; while if it is a large bolt—large in proportion to the thickness of the sheet—the sheet itself will give somewhat in the direction of the strain, and thus relieve the stay-bolt. Another matter tending to increase the life of the stay-bolt is to increase its length. Other things being equal, the longer the bolt the longer will be its life.

Mr. R. C. BLACKALL—Mr. President, we have had no experience with Belpaire boilers, but I must say that our experience with the Wootten firebox and radial stays is not satisfactory. We had several of those crown sheets falling down. I have read in the past year of a large number of boiler explosions throughout the country, and I presume we have representatives of roads here upon which they happen, and I would like to know what class of boilers it was that they had that trouble with.

Mr. VAUCLAIN—Mr. President, we have built, I suppose, more Wootten boilers than any other builders in the United States, and I can safely say that with the Wootten boilers we have built we have had no more trouble

than from any other type of boilers. The Wootten boilers that have exploded and that we have examined into have exploded from the same causes as other makes of boilers. Some explosions have been due to low water, and some to the fact that the boiler has been allowed to go out by the inspector without proper repairs being made to it. The report that a number of boilers had exploded lately has been due to the fact that explosions took place on the Reading Railroad, and to my knowledge only two of the explosions that took place on that road were of Wootten boilers. The others were crown-bar boilers and the remaining one was a radial-stay boiler. The crown-bar boiler broke, I believe, from weakness; the radial-stay from low water; the Wootten from the same cause. We build the Wootten boiler for 200 pounds steam pressure. I have known them to run four years without a broken stay-bolt.

Mr. A. E. MITCHELL—We have about seventy-five Wootten boilers running to-day on the Erie system. Of these boilers we have only had one that has given any trouble, and that was on account of low water. The boilers are giving us excellent service. They are carrying from 150 to 185 pounds. We have no more trouble with them than with other boilers. They are giving us excellent services in every respect.

The discussion was closed on motion of Mr. Sprague.

AIR-BRAKES.

The PRESIDENT—We will now take up the next order of business, which is the report of the Committee on Air-Brake Standards and Inspection and Care of Air-Brakes.

Secretary SINCLAIR—This is a very voluminous report that was submitted last year, and it went over because the Master Car Builders' Association did not agree to it. It is brought up by a joint committee from both associations, and it is very desirable that the action of the two associations should be uniform. Mr. Blackall, the chairman of both committees, has the recommendations that are made by the other association and the changes that were regarded as necessary to make the report satisfactory. I would suggest that he read the changes, or put before the meeting the changes proposed, and what will make the report satisfactory all around.

Mr. BLACKALL read the report, as follows:

SUPPLEMENTARY REPORT OF COMMITTEE ON AIR BRAKE AND SIGNAL INSTRUCTIONS.

We also offer for your consideration the following supplementary recommendations, which were offered and adopted by the M. C. B. Association:

I. Since it has been shown that the packing ring of the piston in the engineer's brake-valve is, in some cases, sufficiently tight

to prevent an accompanying reduction of pressure in the chamber to which the air gauge is attached, when the train-pipe pressure is reduced by leaks, it does not appear to be safe to rely upon the test recommended in the fourth paragraph on page 6 of the report. It is also shown that, in engineer's brake-valves having an excess pressure valve, air from the main reservoir might, under some circumstances, leak past the excess pressure valve sufficiently to compensate for the loss from leaks in the train pipe, if the test were made with the handle in the running position, as has been suggested. Such a compensation is certain to occur with engineer's brake-valves of the most recent construction, in which the excess pressure valve has been replaced by a reducing valve. Such a method for testing for train-pipe leaks is therefore unsafe.

The Committee believes that, while a test for leakage is very important, it would be better to omit it altogether than to require one which may be ineffectual, and we recommend that the fourth paragraph of page 6 be omitted entirely and that the paragraph next following it be amended so that it shall read as follows:

"When the locomotive has been coupled to the train and the brakes have been charged with an air pressure of seventy pounds, the engineman shall, at a signal from the inspector of trainmen, apply the brake and leave them so applied," etc.

An amendment, corresponding to that adopted for this leakage test, will also be necessary in the answer to question 78 of the catechism.

II. We recommend that the sentence in italics, in the fifth paragraph of page 6, be amended by striking out the last two words, "heavy grades," and inserting in their stead the words "such grades as may be designated by special instructions."

This will make the testing of brakes before descending grades subject to the same conditions as those which regulate the use of the pressure retaining valves upon page 12.

The adoption ot this amendment will necessitate a similar change in the first paragraph of page 10 and in the answer to question 53. Question 112 should then also be amended to read as follows:

"How should you proceed to test the air-brakes, before start-

ing out after a change in the make-up of a train, or before descending certain specially designated grades?"

III. Your committee begs to offer some other recommendation, since it appears to many to be desirable to designate not only maximum and minimum limits of brake piston travel to guide inspectors as to the extent to which the brake shoe must be taken up, but also a limit to which the piston travel may be allowed to increase before an adjustment is again required. We offer for your consideration the following amendment to the clause concerning the adjustment of brakes, beginning at the bottom of page 14. We recommend that the last sentence of this clause, in the first paragraph of page 15, be stricken out, and that the portion of the clause remaining be prefaced with the following:

"When under a full application the brake piston travel is found to exceed eight inches upon a passenger car or nine inches upon a freight car, the brake-shoe slack must be taken up and the adjustment so made that the piston shall travel not less than five nor more than six inches."

Changes, corresponding to your determination respecting the adjustment of brakes, should also be made in the first paragraph of page 6, in the clause relating to adjustment upon page 13 and in the answers to questions 56, 58, 111, 112 and 131.

AIR-BRAKE AND SIGNAL INSTRUCTIONS.

As approved by the Master Car-Builders' Association and the American Railway Master Mechanics' Association, June, 1892.

GENERAL INSTRUCTIONS.

The following Rules and Instructions are issued for the government of all employés of this railroad, whose duties bring them in contact with the maintenance or operation of the automatic air-brake and train air-signal. They must be obeyed in all respects, as employés will be held responsible for the observance of the same as strictly as for the performance of any other duty.

Every employé, whose duties are connected in any way with the operation of the air-brake, will be examined from time to time as to his qualification for such duties by the Inspector of Air Brakes or any person appointed by the proper authority, and a record will be kept of such examination.

A book of information has been issued in convenient form, giving a omplete explanation of all parts of the air-brake and train air-signal equip-

ment, with directions for the care and operation of the same. Any employé of this railroad will be furnished with a copy of the same upon application at place designated by special notice, and every employé will be held responsible for a full knowledge of his duties in the operation or maintenance of the air-brake or signal equipment. If the directions contained in that book are observed and the rules and instructions herewith are obeyed, no failure of the air-brake at the time when it is needed should occur. If such a failure does occur, it will be assumed that some employé has neglected his duty, and an investigation will be made to ascertain who is responsible for such failure.

INSTRUCTIONS TO ENGINEMEN.

GENERAL.—Engineers, when taking their locomotives, must see that the air-brake apparatus on locomotive and tender is in good working order; that the air-pump and lubricator work properly; that the pump-regulator prevents the train-pipe pressure exceeding a maximum of seventy (70) pounds; that an excess pressure of not less than twenty pounds is maintained in the main reservoir when handle of the engineer's brake-valve is placed in position 2 (Running Position); that the engineer's brake-valve works properly in all different positions of the handle; and that, when the brakes are fully applied, the driver-brake pistons do not travel less than ⅓ nor more than ⅔ of their stroke, and the tender-brake piston does not travel less than 5 nor more than 8 inches.

Engineers must report to roundhouse foreman at the end of the run, any defect in the air-brake or signal apparatus discovered on the road.

MAKING UP TRAINS AND TESTING BRAKES.—The train-pipe under the tender must always be blown out thoroughly before connecting to the train. Be sure to have 70 pounds train-pipe pressure on the engine, with the handle of the engineer's valve standing in position 2, before connecting to the train.

When the locomotive has been coupled to the train and it has been charged with an air-pressure of 70 pounds, the engineer shall, at a signal from the inspector or trainman, apply the brakes and leave them so applied until the brakes on the entire train have been inspected and the signal is given to release. He shall then release the brakes, and shall not leave the station until it has been ascertained that all brakes are released and he has been informed by the inspector or conductor that the brakes operate all right. This test must be made after each change in the make-up of the train, and before starting down such grades as may be designated by special instructions. Where the train air-signal is used, the signal to release the brakes, in testing, will be given from the rear car of the train, to show, that the signal connections have been properly made.

SERVICE APPLICATION.—In applying the brakes to steady the train on descending grades, or for reducing the speed for any purpose, be very careful not to make too great a reduction of pressure in the outset, as the speed of the train will be too quickly or too much checked, and it will be neces-

sary to release the brakes and apply them again later, perhaps repeating the operation. *Apply the brakes lightly at a sufficient distance from the stopping point, and increase the braking force gradually, as is found necessary, so as to make the stop with one application, or at the most two applications of the brakes.*

With freight trains which are only partially equipped with the air-brake, great care must be used to apply the brakes with only from six to eight pounds reduction, and to allow the slack of the train to be taken up before further application is made, in order to prevent shocks, which otherwise may be serious.

In making a service stop with a passenger train, *always release the brakes a short distance before coming to a dead stop*, except on heavy grades, to prevent shocks at the instant of stopping. Even on moderate grades, it is best to do this, and then, after release, to apply the brakes lightly, to prevent the train starting, so that when ready to start, the release will take place quickly. This does not apply to freight trains, upon which the brakes must not be released until the train has stopped.

EMERGENCY APPLICATIONS.—The emergency application of brakes must not be used, except in actual emergencies.

BRAKES APPLIED FROM AN UNKNOWN CAUSE.—If it is found that the train is dragging at any time without a rapid fall of the black pointer, move the handle of the engineer's valve into the full release position for a few seconds, and then return it to the running position.

If, however, the brakes go on suddenly, with a fall of the black pointer, it is evidence that (*a*) a conductor's valve has been opened, (*b*) a hose has burst or other serious leak has occurred, or (*c*) the train has parted.

In such an event, place the handle immediately in position 3, to prevent the escape of air from the main reservoir, and leave it there until the train has stopped, the brake apparatus has been examined and a signal to release is given.

BRAKING BY HAND.—*Never use the air-brake* when it is known that the trainmen are operating the brake of the air-brake cars by hand, as there is danger of injury to the trainmen by so doing.

CUTTING OUT BRAKES.—*The driver and tender brakes must always be used automatically at every application of the train brakes*, unless defective—except upon such grades as shall be designated by special instructions.

When necessary to cut out either driver or tender-brake, on account of defects, it shall be done by turning the handle of the four-way cock in the triple-valve down to a position midway between a horizontal and a vertical position, and leaving the bleed-cock open.

DOUBLE HEADERS.—When two or more engines are coupled in the same train the brakes must be connected through to and operated from the head engine. For this purpose a cock is placed in the train-pipe just below the

engineer's valve. The engineer of each engine, except the head one, must close this cock and place the handle of the engineer's valve in position 2. He will start his air-pump and let it run as though he were going to use

THE ENGINEER'S BRAKE AND EQUALIZING VALVE AND DUPLEX AIR-GAUGE.

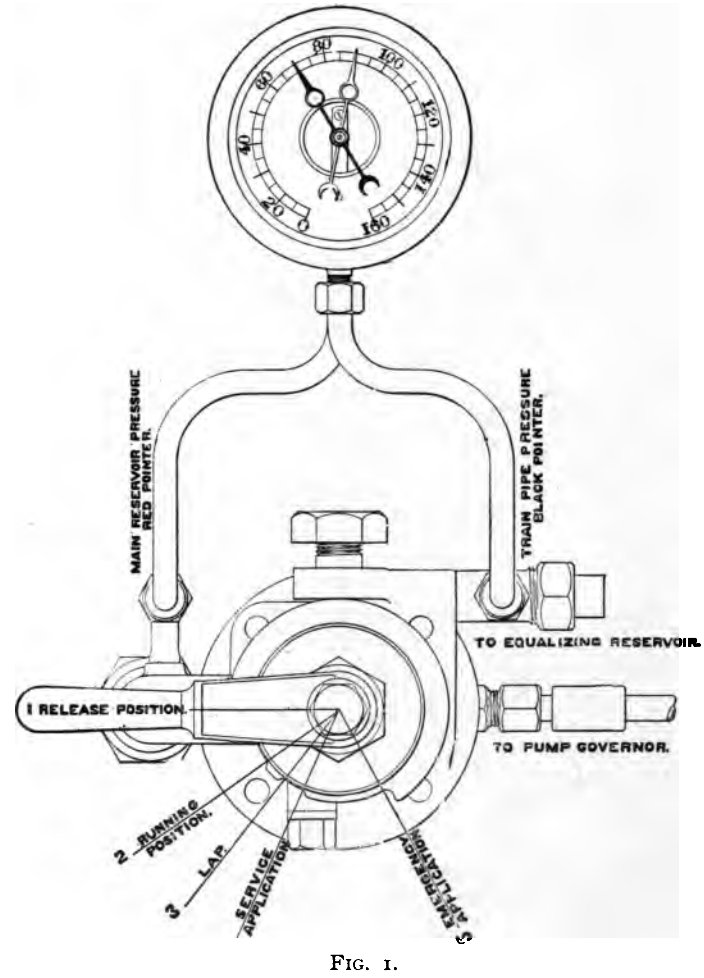


FIG. 1.

the brake for the purpose of maintaining air pressure on his engine and enabling him to assume charge of the train-brakes should occasion require it.

AN EXTRA AIR-BRAKE HOSE AND COUPLING must always be carried on

the engine for repairs in case of a burst hose. Upon engines having the air-signal a signal-hose and coupling must also be carried for the same purpose.

INSTRUCTIONS TO TRAINMEN.

MAKING UP TRAINS AND TESTING BRAKES.—When the engine has been coupled to the train, or when two sections have been coupled together, the brake and signal couplings must be united, the cocks in the train pipes—

THE ANGLE COCK.

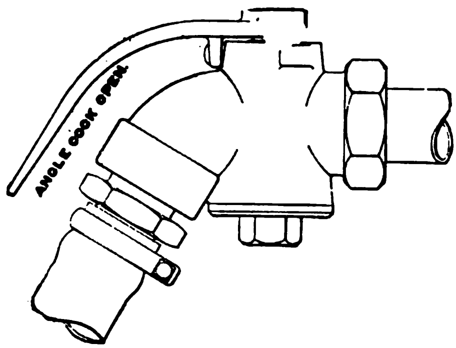


FIG. 2. ANGLE COCK OPEN.

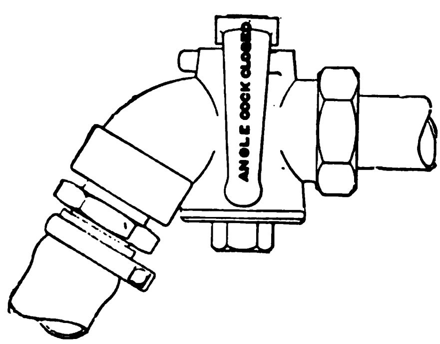


FIG. 3. ANGLE COCK CLOSED.

both brake and signal—must all be open, except those at the rear end of the last car, which must be closed, and the hose hung up properly in the dummy coupling.

After the engineer has charged the train with air he must then be signaled to apply the brakes. When he has done so the brakes of each car must be examined to see if they are properly applied. When it is ascertained that each brake is applied the engineer must be signaled to release

the brakes. When the train air-signal is to be used the signal to the engineer to release the brakes must be given by means of the air-signal from the rear car of the train. The brakes of each car must then be examined to see that each is released.

THE PLAIN STRAIGHT-WAY COCK.

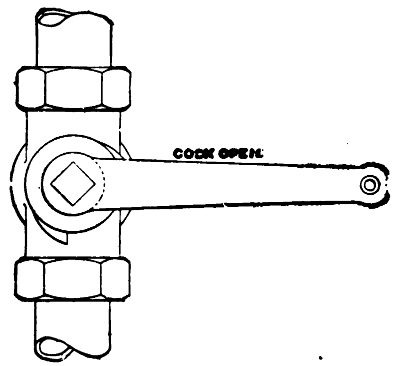


FIG. 4. COCK OPEN.

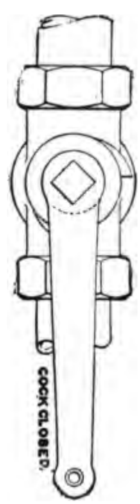


FIG. 5. COCK CLOSED.

If any defect is discovered it must be remedied and the brakes tested again—the operation being repeated until it is ascertained that everything is right. The conductor and engineer must then be notified that the brakes

are all right. This examination must be made every time any change is made in the make-up ot the train and before starting down such grades as may be designated by special instructions. At points where there are no inspectors trainmen must carry out these instructions. No passenger train must be started out from an inspection point with the brakes upon any car cut out or in a defective condition without special orders from the proper officers. The air-brakes must not be alone relied upon to control any freight train with a smaller proportion of cars with the air-brake in service than the division time-card specifies. When hand-brakes are also used they must be applied upon those cars next behind the air-braked cars.

DETACHING ENGINE OR CARS.—First close the cocks in the train-pipes at

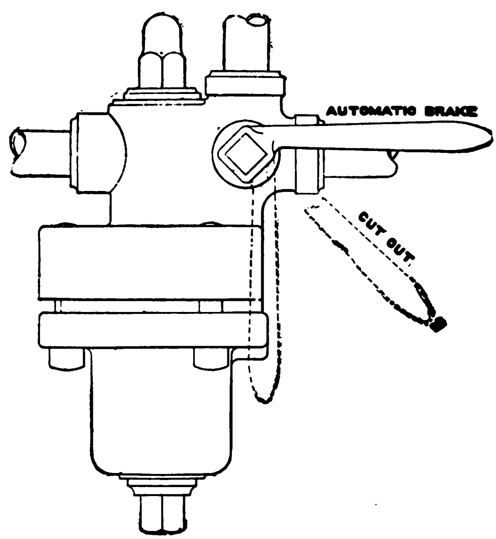


FIG. 6.—THE PLAIN AUTOMATIC TRIPLE VALVE.

the point of separation, and then part the couplings, invariably by hand. If the brakes have been applied do not close the cocks until the engineer has released the brakes upon the whole train.

COUPLINGS FROZEN.—If the couplings are found to be frozen together or covered with an accumulation of ice, the ice must first be removed and then the couplings thawed out by a torch to prevent injury to the gaskets.

BRAKES STICKING.—If brakes are found sticking, the engineer must be signaled to release them. If he cannot do so and calls for release, or if brakes are applied to detached cars, the release may be effected by opening the smaller cock in the auxiliary reservoir until the air begins to release through the triple-valve, when the reservoir-cock must immediately be closed.

TRAIN BREAKING INTO TWO OR MORE PARTS.—First close the cock in the train-pipe at the rear of the first section and signal the engineer to release the brakes. Having coupled to the second section, observe the rule for making up trains—first being sure that the cock in the train-pipe at the rear of the second section has been closed, if the train has broken into more than two sections. When the engineer has released the brakes on the second section the same method must be employed with reference to the third section, and so on. When the train has been once more entirely united the brakes must be inspected on each car to see that each is released before proceeding.

CUTTING OUT THE BRAKE ON A CAR.—If, through any defect of the brake apparatus while on the road, it becomes necessary to cut out the brake upon any car, it may be done by closing the cock in the cross-over pipe near the center of the car where the quick-acting brake is used, or by turning the handle of the cock in the triple-valve to a position midway be-

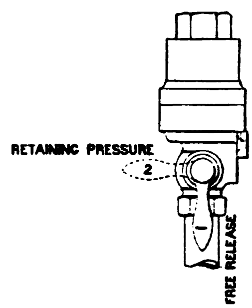


FIG. 7.—THE PRESSURE RETAINING VALVE.

tween a horizontal and vertical where the plain automatic brake is used. When the brake has been thus cut out, the cock in the auxiliary reservoir must be opened and left open upon passenger cars, or held open until all the air has escaped from the reservoir upon freight cars. *The brake must never be cut out upon any car unless the apparatus is defective*, and when it is necessary to cut out a brake the conductor must notify the engineer and also send in a report stating the reasons for so doing.

CONDUCTOR'S VALVE.—Should it become necessary to apply the brakes from the train, it may be done by opening the conductor's valve, placed in each passenger equipment car. *The valve must be held open until the train comes to a full stop, and then must be closed again.*

This method of stopping the train must not be used except in case of emergency.

BURST HOSE.—In the event of the bursting of a brake hose, it must be replaced and the brakes tested before proceeding, provided the train be

in a safe place. If it is not, the train-pipe cock immediately in front of the burst hose must be closed, and the engineer signaled to release. All the brakes to the rear of the burst hose must then be released by hand, and the train must then proceed to a safe place where the burst hose must be replaced and the brakes again connected and tested as in making up a train.

BRAKES NOT IN USE.—When the air-brakes are not in use, either upon the road or in switching, the hose must be kept coupled between the cars or hung up properly to the dummy couplings.

PRESSURE RETAINING VALVE.—When this valve is to be used, the trainmen must, at the top of the grade, test the brakes upon the whole train, and must then pass over the train and turn the handles of the pressure retaining valves horizontally (position 2) upon all or a part of the cars, as may be directed. At the foot of the grade the handles must all be turned downward again. (Position 1.) Special instructions will be issued as to the grades upon which these valves are to be used.

TRAIN AIR SIGNAL.—In making up trains, all couplings and car discharge valves on the cars must be examined to see if they are tight. Should the car discharge valve upon any car be found to be defective while on the road, it may be cut out of use upon that car by closing the cock in the branch pipe leading to the valve. The conductor must always be immediately notified when the signal has been cut out upon any car, and he must report the same for repairs.

In using the signal, pull directly down upon the cord during one full second for each intended blast of the signal whistle, and allow two seconds to elapse between the pulls.

REPORTING DEFECTS TO INSPECTORS.—Any defect in either the air-brake or air-signal apparatus discovered upon the road must be reported to the inspector at the end of the run; or, if the defect be a serious one in passenger service, it must be reported to the nearest inspector, and it must be remedied before the car is again placed in service.

INSTRUCTIONS TO ENGINE-HOUSE FOREMEN.

GENERAL.—It is the duty of the engine-house foremen to see that the air-brake and signal equipment is properly inspected upon each engine after each run. It must be ascertained that all pipe joints, connections and all other parts of the apparatus are air-tight, and that the apparatus is in good working order.

AIR-PUMP.—The air-pump must be tested under pressure, and if found to be working imperfectly in any respect, it must be put into thoroughly serviceable condition.

PUMP GOVERNOR.—The pump governor should cut off the steam supply to the pump when the train-pipe pressure has reached seventy (70) pounds. If it does not, it must be regulated to do so.

ENGINEER'S BRAKE-VALVE.—This valve must be kept clean and in per-

fect order. With the handle in position 2, the main reservoir pressure must not be less than twenty pounds greater than train-pipe pressure. The valve must be tested with the handle in positions 4 and 3, to note that the equalizing piston responds promptly, and that there are no leaks from port to port under the rotary disc valve.

Adjustment of Brakes.—The driver-brakes must be so adjusted that the piston travels not less than one-third nor more than two-thirds of their stroke. When the cam-brake is used care must be taken to adjust both cams alike, so that the point of contact of the cams shall be in line with the piston-rod. The tender-brake must be adjusted by means of the dead-truck levers, so that the piston travels not less than five nor more than six inches when the air-brake is applied and the hand-brake is released. This adjustment must be made whenever the piston travel is found to exceed eight inches.

Brake Cylinders and Triple Valves.—These must be examined and cleaned once every six months, and the cylinders oiled once in three months. If the driver-brake cylinders are in a position to be affected by the heat of the boiler, they must be oiled more frequently. A record must be kept of the dates of last cleaning and oiling for each engine.

Draining.—The main reservoir, and also the drain-cup in the train-pipe under the tender must be drained by accumulation after each trip. The auxiliary reservoirs and triple-valves must also be drained frequently, and daily in cold weather, and the train-pipe under the tender blown out.

Air Signal.—The train air-signal apparatus must be examined and tested by opening and closing the cock in the signal-pipe, at the rear of the tender, to see that the whistle responds properly. A pressure-gauge must be applied to the air-signal pipe, once each month, to ascertain that the reducing-valve maintains the proper pressure of twenty-five pounds per square inch in the train signal-pipe.

INSTRUCTIONS TO INSPECTORS.

General.—It is the duty of all inspectors to see that the couplings, the pipe-joints, the conductor's valves, the air-signal valves, and all other parts of the brake and signal apparatus are in good order and free from leaks. For this purpose they must be tested under a full air-pressure of seventy pounds, and any defects found must be remedied. No passenger train must be allowed to leave a terminal station with the brake upon any car cut out, or in a defective condition, without special orders from the proper officer.

If a defect is discovered in the brake apparatus of a freight car, which cannot be held long enough to give time to correct such defect, the brake must be cut out and the car properly carded, to call the attention of the next inspector to the repairs required.

The division time-card rules specify the smallest proportion of freight

cars, with the air-brakes in good condition, which may be used in operating the train as an air-brake train.

Making Up Trains and Testing Brakes.—In making up trains, the couplings must be united and the cocks at the ends of the cars all opened, except at the rear end of the last car, where the cocks must be closed and the couplings properly hung up to the dummy couplings. After the train is charged, the engineer must be signaled to apply the brakes. When the brakes have been applied, they must be examined upon each car to see that they are properly applied. This having been ascertained, the inspector must signal the engineer to release the brakes, using the train air-signal from the rear car, upon passenger trains. He must then again examine the brakes upon each car to note that each is released. If any defect is discovered, it must be corrected and the testing of the brakes repeated, until they are found to work properly upon each car. The inspector must then inform both the engineer and conductor that the brakes are all right.

Cleansing Cylinders and Triple Valves.—The brake cylinders and triple valves must be kept clean and free from gum. They must be examined for this purpose as often as once in six months upon passenger cars, and once in twelve months upon freight cars. The cylinders must be oiled once every three months, by removing the plug from the hole in the cylinder-head for this purpose, and inserting about one-twelfth of a pint of mineral oil, and the dates of last cleaning and oiling marked with chalk upon the cylinder in the places left for such dates opposite the words, which will be stenciled with white paint, in one-inch letters, upon the cylinder, as follows:

Cyl. oiled________________

Cyl. } Cleaned______________
Triple }

The triple valves and auxiliary reservoirs must be frequently drained, especially in cold weather, by removing the plug in the bottom of the triple valve and opening the small cock in the reservoir.

Adjustment of Brakes.—The slack of the brake-shoes must be taken up by means of the dead truck-levers.

In taking up such slack, it must be first ascertained that the hand-brakes are off, and the slack is all taken out of the upper connections, so that the live truck-levers do not go back within 1½ inches of the truck timber or other stop, when the piston of the brake-cylinder is fully back at the release position. When, under a full application, the brake-piston travel is found to exceed eight inches upon a passenger car, or nine inches upon a freight car, the brake-shoe slack must be taken up and the adjustment so made that the piston shall travel not less than five inches nor more than six inches.

Braking Power.—Where the cylinder-lever has more than one hole at the outer end the different holes are for use upon cars of different weights.

It must be carefully ascertained that the rods are connected to the proper holes, so that the correct braking power shall be exerted upon each car.

Repair Parts.—Inspectors must keep constantly on hand for repairs a supply of all parts of the brake and signal equipment that are liable to get out of order.

Hanging up Hose.—Inspectors must see that, when cars are being switched or standing in the yard, the hose is coupled between the cars or properly secured in the dummy coupling.

Responsibility of Inspectors.—Inspectors will be held strictly responsible for the good condition of all the brake and signal apparatus upon cars placed in trains at their stations; they will also make any examination of brake apparatus or repairs to the same, which they may be called upon to do by trainmen.

GENERAL QUESTIONS REGARDING THE USE OF THE AIR-BRAKE AND TRAIN SIGNAL.

GENERAL QUESTIONS.

(All parties who have to do with the use, adjustment, care or repairs of air-brakes should be thoroughly examined on these questions, in addition to the special questions for each class of men following them.

1. Question. What is an air-brake?

Answer. It is a brake applied by compressed air.

2. Q. How is the air compressed?

A. By an air-pump on the locomotive.

3. Q. How does the compressed air apply the brakes?

A. It is admitted into a brake-cylinder on each car, and it pushes out a piston in that cylinder which pulls the brake on.

4. Q. How does the piston get back when the brakes are released?

A. There is a spring around the piston-rod which is compressed when the brakes are applied, and when the air is allowed to escape to release the brakes, this spring reacts and pushes the piston in again.

5. Q. What was the first and simplest form of air-brake?

A. The straight air-brake.

6. Q. How was the straight air-brake applied and released?

A. The engineer applied the brake by admitting air from the reservoir on the locomotive through a train-pipe to all the brake-cylinders, and he released the brakes by first shutting off the reservoir from the train-pipe, and then opening the train-pipe and all the brake-cylinders to the atmosphere, so that the compressed air could escape again.

7. Q. Is the use of the straight air-brake now allowable?

A. No.

8. Q. Why not?

A. Because it has been replaced by an improved form of brake, called the automatic brake.

9. Q. Why is it called an automatic brake?

A. Because it is applied automatically by any derangement which reduces the air pressure in the train-pipe, such as by the bursting of a hose or the parting of a train.

10. Q. What necessary parts has the automatic brake on a car which the straight air-brake has not?

A. One auxiliary reservoir and one triple valve.

11. Q. Where is the compressed air kept ready for use in the automatic air-brake?

A. In the main reservoir on the locomotive, in the smaller or auxiliary reservoir on each car, and in the train-pipe.

12. Q. Where does the compressed air come from directly, that enters the brake cylinder when the automatic brake is applied?

A. It comes from the auxiliary reservoir on each car.

13. Q. How does it get into the auxiliary reservoir?

A. It is furnished from the main reservoir on the locomotive through the train-pipe when the brakes are released.

14. Q. How is the automatic brake applied and released?

A. The automatic brake is applied by reducing the air pressure in the train pipe at the locomotive, or at any other point, and it is released by restoring the pressure in the train-pipe from the main reservoir on the locomotive.

15. Q. Why does the compressed air not enter directly into the brake cylinder from the train-pipe, as in the straight air-brake?

A. Because the triple-valve used with the automatic brake prevents the air from entering directly from the train-pipe to the brake cylinder when the pressure in the train-pipe is maintained or increased.

16. Q. What other uses has the triple-valve?

A. It causes the brake cylinder to be opened to the atmosphere under each car, and releases the brakes when the pressure in the train-pipe is restored from the locomotive, and it opens communication from the train-pipe to the auxiliary reservoir by the same movement; when the pressure in the train pipe is reduced, it closes the openings from the train-pipe to the auxiliary reservoir and from the brake cylinder to the atmosphere, and then opens the passage between the auxiliary reservoir and the brake cylinder by the same movement, so as to admit the air and apply the brakes.

17. Q. How many forms of triple valves are there in use, and what are they called?

A. Two: the plain triple and the quick-acting triple.

18. Q. How can you tell the plain triple from the quick-acting triple?

A. The plain triple has a four-way cock in it, with a handle for operating the cock; the quick-acting triple has no such cock in it, but there is a

plug-cock in the cross-over pipe leading from the train-pipe to the triple, when the quick-acting triple is used.

19. Q. What are these cocks for in both cases ?

A. They are to be used to cut out brakes on one car, without interfering with other brakes on the train, if the brake on that car has become disabled.

20. Q. How does the cock handle stand in the plain triple-valve when the pipe is open for automatic action ?

A. It stands in a horizontal position.

21. Q. In what position does the same handle stand when the brakes are cut out by closing the cock ?

A. It stands at an inclined position midway between horizontal and vertical.

22. Q. Can this cock handle be placed in any other position, and what ?

A. In the older form of plain triple-valve it can be moved to a vertical position.

23. Q. What was this position for, and is it still used ?

A. This was to convert the automatic brake into a straight air-brake, and it was needed when some cars were equipped with straight air-brake and some with automatic brake, but it is not now used.

24. Q. How does the handle of the plug cock in the cross-over pipe, used with the quick-acting triple, stand for automatic action ?

A. It stands with the handle cross-wise with the pipe, and the cock is then open.

25. Q. How does it stand when the cock is closed and the brake cut out of action ?

A. It stands with handle lengthwise of cross-over pipe.

26. Q. How is the train-pipe coupled up between the cars ?

A. By means of a rubber hose on each end of the train pipe, fitted with a coupling at the loose end.

27. Q. How is the train-pipe closed at the rear end of the train ?

A. By closing the cock in the train-pipe at the rear end of the last car.

28. Q. How many such train-pipe cocks are there to a car, on the air-brake train-pipe and on the air-signal train-pipe, and why ?

A. Two for each pipe on each car, because either end of any car may sometimes be at the rear end of the train.

29. Q. How many kinds of train-pipe cocks are there in use at the ends of the cars ?

A. Two.

30. Q. Describe each and give the position of the handles for opened and closed in each case ?

A. The older form of train-pipe cock is a straight plug-cock in the train-pipe, not far from the hose connection ; the handle stands crosswise with the pipe when it is open, and lengthwise with the pipe when closed ;

it is now found principally on the air-signal pipe. The other form of train-pipe cock now used on the air-brake pipe is an angle cock placed at the end of the train-pipe and close to the hose. The handle of the angle cock stands lengthwise with the pipe when open, and crosswise with the pipe when closed.

31. Q. What uses have these train-pipe cocks besides to close the pipe at the rear end of the train?

A. They are to be used to close the train-pipe at both sides of any hose coupling which is to be parted, as when the train is cut in two.

32. Q. Why is it necessary to close the train-pipe on both sides of the hose coupling before it is parted?

A. To prevent the escape of air from the train-pipe which would apply the brakes.

33. Q. How must the hose coupling be parted when it is necessary to do so, and why?

A. The air-brake must first be released on the train, then the adjacent train-pipe cocks must both be closed and the coupling must be parted by hand, to prevent the possibility of injury to the rubber gasket in the coupling.

34. Q. Why must the brakes be fully released before uncoupling the hose between the cars?

A. Because if the brakes are applied upon a detached car, they cannot be released without bleeding the auxiliary reservoir, and thus wasting air.

35. Q. In coupling or uncoupling the hose between cars, what must be done if there is ice upon the couplings?

A. The ice must first be removed and the couplings thawed out, so as to prevent injury to the rubber gaskets in uncoupling, and to insure tight joints in coupling the hose.

36. Q. What must be done with a hose coupling which is not coupled up, such as the rear hose of a train, or any hose on a car which is standing or running, but not in use?

A. It must be placed in the dummy coupling provided for it on each end of each car, in such manner that the flat pad on the dummy will close the opening in the coupling.

37. Q. Why is this important?

A. Because if it is not done properly, dust and dirt will enter the hose, and, when it is again coupled up in service, this dirt will be blown into the triple valve and interfere with its proper working, and will cause it to wear out more rapidly.

38. Q. What pressure should be carried in the train-pipe and auxiliary reservoir?

A. Seventy pounds pressure to the square inch.

39. Q. Why should this pressure be 70 pounds?

A. Because this pressure is necessary to get the full braking force which each car is capable of using, and, if it be exceeded, there will be danger of sliding the wheels.

40. Q. How much pressure can be obtained in the brake cylinder by the ordinary application of the brakes with 70 pounds in the auxiliary reservoir?

A. About 50 pounds pressure to the square inch, with an eight-inch piston travel.

41. Q. Why can only 50 pounds pressure be obtained under these circumstances?

A. Because the air, at 70 pounds pressure in the auxiliary reservoir expands into a larger space when the auxiliary reservoir is opened to the brake cylinder, and, when the pressure has become equalized, it is thus reduced to 50 pounds.

42. Q. How much must the train-pipe pressure be reduced, in order to get 50 pounds pressure in the brake cylinder, in ordinary service?

A. Twenty pounds; or from 70 pounds down to 50 pounds in the train pipe also.

43. Q. Can the brakes be applied so as to get only a portion of this 50 pounds pressure in the brake cylinder, and how?

A. They can be so applied by reducing the train-pipe pressure less than 20 pounds.

44. Q. If the train-pipe pressure be reduced 10 pounds what will the pressure be in the brake cylinder?

A. About 25 pounds.

45. Q. How is this graduated action obtained?

A. By means of the graduating valve in the triple-valve.

46. Q. Is it important to keep all the air-brake apparatus tight and free from leaks?

A. Yes.

47. Q. Why is this important?

A. In order to get full service from the air-brakes, and to prevent the waste of air, and also to prevent the brakes applying automatically by reason of leak in the train pipe.

48. Q. Is it important to know that the train-pipe is open throughout the train and closed at the rear end before starting out?

A. Yes, this is very important.

49. Q. Why is this very important?

A. Because if any cock in the train-pipe were closed, all the brakes back of the cock which is closed would be prevented from working.

50. Q. How can you know that the train-pipe cocks are all open when the train is made up?

A. By testing the brakes; that is, by applying and releasing them, and observing whether they all operate.

51. Q. Do you understand that no excuse will be acceptable for starting out the train without first testing the air-brakes?

A. Yes.

52. Q. Why is this rule absolute?

A. Because the safety of passengers and of property depends upon the brakes being properly coupled up and in an operating condition before the train is started.

53. Q. At what other times should the brakes be tested and how?

A. After each change in the make-up of the train and before starting the train down certain designated grades, and the test should be made with a full application of the brakes.

54. Q. How much air pressure should be carried in the air-signal train-pipe?

A. Twenty-five pounds pressure.

55. Q. Is it important that this train-pipe and its connections be also kept tight?

A. Yes.

56. Q. After taking up the slack of the brake-shoes, how far should the brake piston travel in the cylinders on cars and tenders with a full application of the brake?

A. Not less than 5 inches nor more than 6 inches.

57. Q. What would happen if the piston traveled less than 5 inches when brakes are fully applied?

A. A partial application of the brakes might not close the leakage groove in the brake cylinder provided for the escape of small amounts of air which might leak through the triple-valve when the brakes are released.

58. Q. Why should the piston travel not be permitted to exceed 8 inches on passenger cars and tenders, or 9 inches on freight cars?

A. Because, if it travels further than this when sent out, a little wear of the brake shoes will cause the piston to travel far enough to rest against the back cylinder head when the brakes are applied, and this cylinder head would then take the pressure instead of its being brought upon the brake shoes.

59. Q. How far should the driver brake piston travel with a full application of the brakes, and why?

A. Not less than one-third of the full stroke of the piston, nor more than two-thirds of its full stroke, for reasons similar to those given for cars and tenders.

60. Q. If the brakes stick upon any car so that the engineman cannot release them at any time, how are you to release them?

A. By opening the release cock in the auxiliary reservoir and holding it open until air begins to escape from the triple-valve and then closing it again.

61. Q. What is the pressure retaining valve. and what is its use?

A. The pressure retaining valve is a small valve placed at the end of a pipe from the triple valve, through which the exhaust takes place from the brake cylinder. It is used to retard the brake release on heavy grades and hold the brakes partially applied, so as to allow more time for the engineman to recharge the auxiliary reservoir.

62. Q. What precautions are necessary on every train in regard to hose couplings?

A. Every train must carry at least two extra hose and couplings complete, for use in replacing any hose couplings which may fail or become disabled. These extra hose and couplings to be carried on such part of the train as is required by the rules and regulations.

SPECIAL FOR ENGINEMEN.

63. Q. How should the air pump be started?

A. It should be started slowly, so as to allow the condensation to escape from the steam cylinder and prevent pounding, which is more likely to occur when the air pressure is low.

64. Q. Why should the piston rod on the air-pump be kept thoroughly packed?

A. To prevent condensation in the steam cylinder from running down the rod into the air cylinder and thus getting water in the air-brake service.

65. Q. How should the steam cylinder of the air-pump be oiled, and what kind of oil should be used?

A. It should be oiled as little as necessary through a sight-feed lubricator, and cylinder oil should be used.

66. Q. How should the air cylinder of the air-pump be oiled; what kind of oil, and why?

A. It should be oiled very little by once filling the oil-cup with West Virginia well oil daily. Cylinder oil, lard oil and other animal or vegetable oils must not be used, as their use causes the engineer's brake valve and the triple valves to gum up. The oil must never be introduced through the air inlet ports, as this practice would cause the pump valves to gum up.

67. Q. What regulates the train-pipe pressure?

A. The pump governor.

68. Q. Why should the pump governor prevent the train-pipe pressure exceeding 70 pounds?

A. Because 70 pounds train-pipe pressure produces the strongest safe pressure of the brake shoes upon the wheels. A higher train-pipe pressure is liable to cause the wheels to slide.

69. Q. Why is the equalizing engineer's valve better than the older forms?

A. Because it enables the engineer to apply the brakes more uniformly throughout the train, and with less shock to the train, especially when the quick-acting triple valves are used. It also prevents the brakes from being

kicked off on the forward end of the train when the engineer closes the valve after applying the brakes.

70. Q. Why does the equalizing engineer's valve produce these results in ordinary service stops?

A. Because the engineer does not, in such cases, open the train-pipe to the atmosphere direct, but he only reduces the air pressure above the piston in the engineer's valve, which causes that piston to open the train-pipe to the atmosphere, and to close the opening gradually when the train-pipe pressure has been correspondingly reduced.

71. Q. What does the excess pressure valve in the engineer's valve accomplish, and do you regard it important to have it working properly?

A. It maintains an excess pressure of about 20 pounds in the main reservoir above the pressure in the train-pipe, and it is important that it be kept clean and in working order so as to have this excess pressure to insure release, and for use in recharging the train quickly after the brakes are released.

72. Q. How often should the brake valve be thoroughly cleaned and oiled?

A. At least once every two months.

73. Q. If the rotary disk valve in the engineer's valve is unseated by dirt or by wear, what may be the result, and what should be done?

A. It may be impossible to get the excess pressure; when the brakes have been applied they may keep applying harder until full on, or when they have been applied they may go off. The rotary disk valve should be thoroughly cleaned, and if worn it should be faced and ground to a seat.

74. Q. If the piston in the engineer's valve becomes gummed up or corroded from neglect to clean it, what will be the result?

A. It will be necessary to make a large reduction of pressure through the preliminary exhaust port before the brakes will apply at all, and then the brakes will go on too hard, and will have to be released.

75. Q. When the engine is standing alone and the pump is running, why must the engineer's valve not be left standing in the lap position (No. 3)?

A. Because the main reservoir pressure may become so high that, when the handle of the engineer's valve is again placed in the release position, it will cause the train-pipe and tender auxiliary reservoir to be charged with too high pressure, which might injure the adjustment of the pump governor as well as cause the tender wheels to be slid with the first application of the brakes.

76. Q. How and why should the train-pipe under the tender always be blown out thoroughly before connecting up to the train?

A. By opening the angle cock at the rear end of the tender and allowing the air from the main reservoir to blow through. This blows out the oil, water, scale, etc., which may accumulate in the pipe, and which

would be blown back into the train-pipe and triple valves if not removed before coupling to the train.

77. Q. When the engine is coupled to the train, why is it necessary to have the full train-pipe pressure and the excess pressure on the main reservoir?

A. So that the brakes will all be released and the train quickly charged when the engineer's valve is placed in the release position.

78. Q. Why should the driver brakes always be operated automatically with the train brake?

A. Because it adds greatly to the braking force of the train, and the brakes can be applied alike to all the wheels for ordinary stops, and in an emergency the greatest possible braking force is at once obtained by one movement of the handle.

79. Q. In making a service application of the brakes, how much reduction of the train-pipe pressure from 70 pounds does it require to get the brakes full on?

A. About 20 pounds reduction.

80. Q. What should the first reduction be in such an application, and why?

A. From six to eight pounds, so as to insure moving the pistons in the brake cylinders past the leakage groove, yet not apply the brakes too hard, until the slack in drawbars and drawsprings is first taken up.

81. Q. What is the result of making a greater reduction of pressure than 20 pounds?

A. A waste of air in the train-pipe, without getting any more braking force, and therefore requiring more air to release the brakes.

82. Q. How many applications of the brakes are necessary in making a stop?

A. Generally only one; by applying them lightly at first with six or eight pounds reduction of air in the train-pipe, and afterward gradually increasing the force of the application. Two applications are as many as should ever be required.

83. Q. Why is it dangerous to apply and release the brakes repeatedly in making stops?

A. Because every time the brakes are released the air in the brake-cylinders is thrown away, and, if it is necessary to apply them again before sufficient time has elapsed to recharge the auxiliary reservoirs, the application of the brakes will be weak, and after a few such applications the brakes are almost useless on account of the air having been exhausted from the auxiliary reservoirs.

84. Q. In releasing and recharging the train, how long should the handle of the engineer's valve be left in the release position.

A. Until the train-pipe pressure has risen nearly to 70 pounds again.

85. Q. In making service stops with passenger trains, why should you release the brakes a little before coming to a full stop?

A. So as to prevent stopping with a lurch ; it also requires less time for the full release of the brakes after stopping.

86. Q. In making stops with freight trains, why should the brakes not be released until after the train has come to a full stop ?

A. Because long freight trains are apt to be parted by releasing the brakes at low speed, owing to the unequal brake-shoe friction incident to freight car equipment.

87. Q. In making service stops, why must the handle of the engineer's valve not be moved past the position for service applications ?

A. So as to prevent unnecessary jerks to the train, and the emergency action of the triple-valve when not necessary.

88. Q. If you find the train dragging from the failure of the brakes to release, how can you release them ?

A. By placing the handle of the engineer's valve in the running position until full excess pressure is attained and then throwing it quickly into the release position.

89. Q. When the brakes go on suddenly when not operated by the engineer's valve, and the gauge pointer falls back, what is the cause, and what should you do ?

A. Either a hose has burst, or a conductor's valve has been opened, or the train has parted. In any event, the handle of the engineer's valve must be immediately placed in the lap position to prevent the escape of air from the reservoir.

90. Q. Are the brakes liable to stick on after an emergency application, and why ?

A. The brakes are harder to release after a severe application, because they are on with full force, and it requires higher pressure than usual in the train-pipe to release them again. In this case it is necessary always to have in reserve the excess pressure on the main reservoir to aid in releasing the brakes. With the quick-acting triple-valve this is especially necessary, because air from the train-pipe as well as from the auxiliary reservoir is forced into the brake cylinder when a quick application of the brake is made, thus increasing the pressure in the brake cylinder without the usual reduction of pressure in the auxiliary reservoir, and requiring a high pressure in the train-pipe afterward to cause the brakes to be released.

91. Q. In using the brakes to steady the train while descending grades, why should the air-pump throttle be kept well open ?

A. So that the pump may quickly accumulate a full pressure in the main reservoir for use in recharging the train when the brakes have been released again.

92. Q. In descending a grade how can you best keep the train under control ?

A. First, by commencing the application of the brakes early, so as to prevent too high a speed being reached. Second, by applying the brakes

lightly at first, then increasing the brake pressure as needed, and by slowing the train down just before it is necessary to release the brakes for recharging, so as to give time enough to refill the auxiliary reservoirs before much speed is again attained.

93. Q. If the train is being drawn by two or more engines, upon which engine should the brakes be controlled, and what must the enginemen of the other engines do?

A. The brakes must be controlled by the leading engine, and the enginemen of the following engines must close the cock in the train-pipe just below the engineer's valves. The latter must always keep his pump running and in order, and main reservoir charged, with the engineer's valve in the running position, so that he may quickly operate the brakes if called upon to do so.

94. Q. If the air-signal whistle only gives a weak blast, what is the probable cause?

A. Either the reducing valve is out of order so that the pressure is less than 25 pounds or the whistle itself is filled with dirt or not properly adjusted.

95. Q. If the reducing valve for the air-signal is allowed to become clogged up with dirt, what will the result probably be?

A. The signal-pipe might get the full main reservoir pressure, and the whistle will blow when the brakes are released.

96. Q. If you discover any defect in your air-brake or signal apparatus while on the road, what must you do?

A. If it is something that cannot be readily remedied at once, it must be reported to the engine-house foreman as soon as the run is completed.

97. Q. What is the result if water be allowed to collect in the main reservoir of the brake apparatus?

A. The room taken up by the water reduces the capacity for holding air, and the brakes are more liable to stick. In cold weather also the water may freeze and prevent the brakes from working properly.

SPECIAL FOR ENGINE REPAIRMEN.

98. Q. How often must the air-brake and signal apparatus on locomotives be examined?

A. After each trip.

99. Q. Under what pressure must it be examined?

A. Under full pressure, *i. e.*, 70 pounds on the air-brake train-pipe, 20 pounds excess in the main reservoir, and 25 pounds pressure on the air-signal train-pipe.

100. Q. How will you be sure that proper pressures are upon the two train-pipes?

A. By regulating, and, if necessary, cleaning the pump governor so that it will shut off steam from the pump when 70 pounds train-pipe pressure is reached, and by examining, and, if necessary, cleaning the pressure

reducing valve for the signal train-pipe, so that it maintains 25 pounds pressure in the train-pipe.

101. Q. If you do not obtain 20 pounds excess pressure in the main reservoir when the handle of the engineer's valve is in the running position, what is the cause?

A. Either the excess-pressure valve needs cleaning, or the rotary disk-valve in the engineer's valve is unseated and allows air to leak from one port to another.

102. Q. Why must the air-pump piston-rod be kept well packed?

A. To prevent condensation in the steam cylinder from running down into the air cylinder and getting into the brake-service.

103. Q. How often must the main reservoir and the drain-cup under the tender be drained?

A. After each trip.

104. Q. How often must the triple-valves and the cylinders of the driver and tender-brakes be cleaned and oiled.

A. They must be thoroughly cleaned and oiled with a small amount of mineral oil once every six months, and the cylinders must be oiled every three months. If the driving-brake cylinders are so located that they become hot from the boiler, they may require oiling more frequently.

105. Q. If there are any leaks in the pipe joints or anywhere in the apparatus, what must you do?

A. Repair them before the engine goes out.

106. Q. How is the brake-shoe slack of the cam-driver brake taken up, and what precautions are necessary.

A. By means of the cam-screws, and it is necessary to lengthen both alike, so that when the brake is applied the point of contact of the cams will be in a line with the piston-rod.

107. Q. How is the brake-shoe slack of driver-brakes on a locomotive with more than two pairs of driving-wheels taken up?

A. By means of a turnbuckle or screw in the connecting-rods.

108. Q. How is the slack of the tender-brake shoes taken up?

A. By means of the dead-truck levers; if they will not take it up enough, it must be taken up in the underneath connection, and then adjusted by the dead-lever.

109. Q. How far should the driver-brake piston travel in applying the brakes?

A. Not less than one-third nor more than two-thirds of the full stroke of the piston.

110. Q. What travel of piston should the tender-brakes be adjusted for?

A. Not less than five inches nor more than six inches, and such adjustment must be made whenever the piston travel is found to exceed eight inches.

111. Q. How should you proceed to test the air-brakes before starting out, after a change in the make-up of a train, or before descending certain specially designated grades?

A. After the train has been fully charged with air, the engineman must be signaled to apply the brakes; when he has done so, the brakes must be examined upon each car to see that the air is applied and that the piston-travel is not less than 5 inches nor more than 8 inches, on a passenger car, or 9 inches on a freight car. The engineman must be then signaled to release the brakes, and this signal must be given by the train air-signal from the rear car, if it is in use upon the train; after he has done so, each brake must be examined again to see that all are released. The engineman and conductor must then be notified that the brakes are all right, if they are found so.

112. Q. In starting out a passenger train from an inspection point, how many cars must have the brakes in service?

A. Every car upon the train.

113. Q. When might you cut out a brake upon a passenger car?

A. Never; unless it gets out of order while on the run, in which case it must be reported to the inspector at the end of the run, or upon the first opportunity which may give sufficient time to repair it.

114. Q. If a hose bursts upon the run what must be done, if the train is in a safe place?

A. The hose must first be replaced by a good one, and the engineman then signaled to release the brakes. The train must not proceed until the brakes have been reconnected and tested upon the train to see that all are working properly.

115. Q. If the train is not in a safe place when the hose bursts, what must be done?

A. The train-pipe cock immediately ahead of the burst hose must be closed and the engineer signaled to release the brakes. The brakes at the rear of the burst hose must then be released by bleeding the auxiliary reservoirs, and the train must then proceed to a safe place to replace the hose and connect up the brakes, after which the brakes must be tested.

116. Q. If the train breaks in two, what must be done?

A. The cock in the train-pipe at the rear end of the first section must be closed, and the engineman signaled to release the brakes. The two parts of the train must then be coupled, the hose connected and the brakes again released by the engineman. When it is ascertained that the brakes are all released, the train may proceed.

117. Q. Explain how the pressure retaining-valves are thrown into action or thrown out of action, and when this must be done.

A. The pressure retaining-valve is thrown into action by turning the handle of the valve to a horizontal position, and it is thrown out of action

again by placing this handle in a vertical position pointing downward. This handle should be placed in a horizontal position at the top of a heavy grade, and it should always be returned to a vertical position at the foot of the grade, as otherwise the brakes will drag on any cars which still have the handle of the pressure retaining-valve in the horizontal position.

118. Q. If the brake of any car is found to be defective on the run, how should you proceed to cut it out?

A. By closing the cock in the cross-over pipe of the quick-acting brake, or in the triple-valve of the plain automatic brake, and then opening the release-cock in the auxiliary reservoir upon that car, leaving it open, if a passenger car, or holding it open until all the air has escaped from it, if a freight car.

119. Q. When it is necessary to cut out a defective brake upon a car, why should it always be cut out at the triple-valve and never by the train-pipe cock at the end of the car, even if it is the last car of the train?

A. The train-pipe should always be open from the engine to the rear end of the last car, so that if the train breaks in two the brakes will be automatically applied before the parts of the train have separated sufficiently to permit damage to be done by their coming together again, and so that the brakes may be applied with the conductor's valve upon any car.

120. Q. Should the train-pipe burst under any car, what must be done?

A. The train must proceed to the nearest switching point, using the brakes upon the cars ahead of the one with the burst pipe, where the car with the burst pipe must be switched to the rear of the train; the hose must then be coupled up to the rear car and the cock at the rear end of the next to the last car opened and the cock at the forward end of the last car closed, so that if the train should part between the last two cars the brakes will be applied.

121. Q. What is the conductor's valve, and what is its use?

A. It is a valve at the end of the branch-pipe leading from the train brake-pipe upon each passenger car; it is to be opened from the car in any emergency when it is necessary to stop the train quickly, and only then. When used it should be held open until the train is stopped, and then it should be closed.

122. Q. What is the air-signal for, and how is it operated?

A. It is to signal the engineman, in place of the old gong signal, and it is operated by pulling directly downward on the cord one second for each signal given and allowing two seconds to elapse between pulls.

123. Q. If the car discharge-valve on the air-signal system is out of order or leaking on any car, how can you cut it out?

A. By closing the cock in the branch-pipe leading from the train signal-pipe to the discharge-valve; to do so the handle of this cock should be placed lengthwise with the pipe.

124. Q. How is the slack taken up so as to secure the proper adjustment of piston travel?

A. By means of the dead truck-lever, and if that is not sufficient, one or more holes must be taken up in the underneath connection and the adjustment then made by the dead truck-lever.

SPECIAL FOR INSPECTORS.

125. Q. Do you understand that no passenger train may be started out with any of the brakes cut out of service?

A. I do.

126. Q. Why is it important that no leaks should occur in the air-brake service?

A. Because they would interfere with the proper working of the brakes and might cause serious damage.

127. Q. What must be done with the air-brake or air-signal couplings when not united to other couplings?

A. They must be secured in the dummy coupling, so that the face of the dummy coupling will cover the opening of the hose coupling, so as to prevent dust and dirt from entering the hose.

128. Q. If air issues from the release port of the triple-valve when the brakes are off, what is the eause?

A. It is probably due to dirt on the rubber-seated emergency-valve.

129. Q. How often must the cylinder and triple-valves be examined, cleaned and oiled?

A. As often as once every six months on passenger cars and once in twelve months on freight cars, and the cylinders must be oiled once every three months with a small quantity of mineral oil. The dates of the last cleaning and oiling must be marked with chalk on the cylinders.

130. Q. To what travel of piston must the brakes be adjusted?

A. Not less than 5 inches nor more than 6 inches, and this adjustment must be made whenever the piston travel is found to exceed 8 inches on a passenger car or 9 inches on a freight car.

131. Q. How is the slack taken up so as to secure this adjustment?

A. By means of the dead truck-lever, and if that is not sufficient, one or more holes must be taken up in the underneath connection and the adjustment then made by the dead truck-lever.

132. Q. What are the different holes in the outer end of the cylinder-levers for, and why must the connections be pinned to the proper hole for each car?

A. These holes are to enable the adjustment of the brake pressure to be made according to the weights of different cars. The connection must be made to the proper hole in each case, according to the weight of the car, so as to give proper braking power; otherwise the brake will be inefficient, or the wheels may be slid under the cars.

On motion of Mr. Briggs the report was received.

On motion of Secretary Sinclair the recommendations of the committee were adopted.

The PRESIDENT—If you wish to discuss the report, gentlemen, it is before you.

Mr. LAUDER—I do not think it is necessary to discuss this report, inasmuch as the association has adopted its recommendations. I move that the discussion be closed.

The motion was carried.

The PRESIDENT—That, gentlemen, finishes the committee reports, and we will now take up the next order, which is routine and miscellaneous business. The first matter will be the report of the Committee on Subjects for Investigation.

Secretary SINCLAIR read the report of the Committee on Subjects, as follows:

SUBJECTS FOR INVESTIGATION.

Your Committee on "Subjects" beg to report that in addition to the continued subjects, viz.:

1. Compounds. 2. Standard Tests. 3. Steel Tests; and 4. Exhaust Pipes, they suggest the following: 5. Standard diameters for wheel centers and tires, of both larger and smaller sizes than those now accepted. Very large diameters of driver are now coming into use, and we have no standard for steel-tired truck wheels. This subject should include uniformity of rolled outline for standard tires. 6. Boiler attachments; means for increasing their safety and also lessening the number of holes in boiler. 7. Extent, utility and cost of malleable castings, to take the place of small expensive forgings or steel castings. 8. Attachments between engine and tender to increase safety and prevent tender mounting foot-plate; also footsteps and handrails (the Committee to make a suggestion to the association of an approved form). 9. Best means of preventing the smoke nuisance when using soft coal in cities. (This subject is of importance and the sense of this association would be of use in dealing with municipalities.) 10. Best forms of tender frame and tender-truck frame, either of wood or metal. 11. Limiting weight on driving wheels and the effect of varying weight on tire and on permanent way; including definition of best tire material to meet excessive weights.

J. DAVIS BARNETT,
WM. SMITH,
GEO. GIBBS.

Mr LAUDER—I move that the report be received and its recommendations adopted.

Mr. FORNEY—I would like to amend by adding that a Committee on the Economy of Simple Engines be appointed to report next year.

The PRESIDENT—I think I will have to rule that out of order, Mr. Forney. We have got more subjects now than we can handle. I heard no second to Mr. Forney's motion, however.

Mr. Lauder's motion was then put and carried.

The Committee on Resolutions, through Mr. Marshall, presented the following report:

REPORT ON RESOLUTIONS.

Resolved, That the thanks of this convention be given to the Village of Saratoga, and to its president, Mr. Mitchell, for the cordial welcome extended to us; to the Schenectady Locomotive Works, and to the Delaware & Hudson Canal Co., for the pleasant and instructive visit to the shops of the former company by so many members; to Mr. R. C. Blackall, superintendent of motive power of the Delaware & Hudson Canal Co., and to Mr. H. G. Young, second vice-president of the same company, for their assistance in making arrangements for the convenience and comfort of the members while at Saratoga, and for courtesies extended to members in the way of transportation; to the Fitchburg Railroad Co., for the transportation facilities extended to them through Mr. O. Stewart, superintendent of motive power; to our friends who have furnished such unexcelled entertainment to the members and their ladies; to the *Railway Age* and *Northwestern Railroader* for daily reports of the proceedings of the convention; to the officers of the association for their earnest work, and the efficient manner in which all the business of the association has been handled during the year, and to the proprietor of Congress Hall for his successful endeavors to make our stay in Saratoga a pleasant one. And be it further,

Resolved, That the hearty thanks of this association be extended to the Chicago, Milwaukee & St. Paul Railway Company, for its liberality in providing facilities for the testing of such locomotives as the committee of this association desired to place under trial; to the Baldwin Locomotive Works, for the assistance which they rendered the same committee, and to all others who have improved and broadened the work of our association by cooperating with its committees. W. H. MARSHALL.

Mr. LAUDER—I move that the report of the Committee on Resolutions be received and spread on the minutes of the meeting.

The motion was carried.

The PRESIDENT—I wish to call your attention again to the flourishing condition of our association. Eighteen new members signed the roll since the association opened its convention on Monday morning. This is an addition to the fifty-three that were reported by the secretary as signing during the year. One hundred and seventy-nine members answered the roll or have been present at the meeting.

NEXT PLACE OF MEETING.

The PRESIDENT—I would ask if any member has anything to offer at this time. Wouldn't it be well for the members to suggest some place of meeting, under this head, for our next annual convention, for the benefit of the Executive Committee?

Secretary SINCLAIR—I might mention that Waukesha would be a place that could supply good hotel accommodations for the convention. There are several very large hotels, and that is always to be considered where a convention meets. It is about 100 miles from Chicago.

The PRESIDENT—Put-in-Bay has a very large hotel and can accommo date all the members, without doubt.

Mr. SPRAGUE—I hope the members will realize the difficulty in meeting in a large city such weather as this. I hope they will give us some place where it is cool, like this. I think it would be a great mistake to go to Milwaukee, or any other city.

Mr. ROBERTS—It looks as though it would be almost necessary to get us in the neighborhood of the World's Fair, and it would be folly to advocate Chicago at that particular time. Hotel accommodations will be hard to get. I think it would be well to go to some point near Chicago, and I would suggest Waukesha.

Mr. LEEDS—I think Saratoga has proved itself a first-class place, for one reason—it has not been convenient enough to other attractions for the members to run off during meetings, and we have had very full meetings and good meetings. I think if we should be near Chicago that members will be running off, the same as at Cape May last year. I think that Put-in-Bay is just far enough and none too far. Therefore, I would recommend Put-in-Bay, as I understand that they have fine hotel accommodations.

Mr. SPRAGUE—There is one advantage about Put-in-Bay—we could probably unite with the Car Builders without any trouble. Waukesha is a place which they have not voted for, I believe.

Secretary SINCLAIR—I would explain, gentlemen, that these votes are merely indication votes. The decision will be come to by the joint committees of the two associations, and the object of any vote at any of the conventions is just to show the preferences of the members. The decision would depend on the arrangements that could be made and on what the committee think the most desirable place when they have examined it.

Mr. Sprague—I understand that the committee has no right to take any place except one of the three places we have voted on without getting our vote again.

The President—I do not think so, Mr. Sprague. I think the arrangements are in the hands of the Executive Committee.

Mr. Sprague—We found that we could not confine ourselves to one place, because they took advantage of it, so we voted on three places, giving the Executive Committee the choice between the three, but not outside of that. That is my understanding.

Mr. Briggs—That was my understanding, Mr. President. Places are nominated and the Executive Committee chooses from those places.

Mr. Setchel—Is that the decision of the chair—that any place can be selected by the joint committees?

The President—I think that has been our practice.

Mr. Setchel—It seems to me that according to our by-laws the place selected must be from the three highest voted for.

Secretary Sinclair—I will read the rule under which this voting is done, on page 19 of the report of last year:

"*Resolved*, That we, the committee appointed by our respective associations, recommend a change in the Constitution or By-Laws, or both, of each of the associations, to arrange that the Master Car Builders' Association will meet on the second Wednesday in June, and the American Master Mechanics' Association will meet on the Monday following the second Wednesday in June.

"*Resolved*, That we recommend the change in the Constitution or By-Laws, or both, in each of the associations, so that the officers of each association constitute a committee of five to jointly fix the place of each annual meeting at least six months before the meeting; the Committee of the American Railway Master Mechanics' Association to consist of the President, two Vice-Presidents, Secretary and Treasurer; the Committee of the Master Car Builders' Association to consist of the President, three Vice-Presidents and Secretary."

The Convention adopted this as a rule that the place of meeting should be left to that joint committee.

Mr. Setchel—I had forgotten that for the moment. But I want to say, in regard to the place of meeting, that there will be a great many members that will come to the association next year, if the meeting be held in the vicinity of Chicago, and yet Chicago does not seem to be the best place to meet. I do not believe we could get a hotel that will accommodate the members in Chicago next year. But as my friend Roberts has suggested, there is a point within less than 100 miles of Chicago, and that is Waukesha, where they have a very fine hotel that can take care of this association without any trouble whatever. Two years ago when Mr. Hickey was still on the Milwaukee, Lake Shore & Western road he told me—and I received the same assurance from their general manager—that if the association would come to Waukesha they would furnish them with all the trains and transportation that they wanted between Chicago and Waukesha. Of course we would not want them to be so generous with their accommoda-

tions that the members could get off from the meetings, but members are hardly liable to go 100 miles and leave their meetings. It seems to me that Waukesha would be a mangificent place. I hope that that place will be selected.

The PRESIDENT—All those in favor of Waukesha will please rise to their feet.

Forty-six members arose.

The PRESIDENT—Those in favor of Put-in-Bay will rise.

Three members arose.

Mr. LEEDS—I am very glad to see this association come out so strong in favor of water. (Laughter.)

The PRESIDENT—It is five minutes to the hour at which we hold our noon discussion.

Mr. SPRAGUE—I would inquire if the Secretary has any questions for that hour.

Secretary SINCLAIR—I have no questions for that hour.

The PRESIDENT—If there is no objection, we will proceed to the election of officers.

ELECTION OF OFFICERS

Mr. SETCHEL—I know that it is contrary to the Constitution that any nominations for officers should be made, and I would not say a word about that matter were it not for the fact that the man for whom I believe a majority would vote for President is by reason of severe afflictions to his family away from us. I refer to John Hickey of the Northern Pacific—a magnificent fellow, as those who know him can bear testimony, and one who would make a good president. I know, because I have talked with our president on the subject, that it is his expectation to retire from the office, and I hope the members will compliment Mr. Hickey in his absence by voting for him, and that they will then appoint a committee to notify him of his election and extend sympathy to him in his affliction.

And now, just a word, Mr. President, in regard to myself. I have been connected with this association ever since the second meeting, and I have a great many friends in the association, and some of them, thinking to do me a kindness, or a compliment—I am not sure which—have spoken to me about becoming an officer in the association. I want to say most emphatically now that I am not a candidate for any position. I do not want a single member of this association to vote for me for anything, and if they will respect my wishes I will be very glad.

Mr. SPRAGUE—I do not know that it will be necessary to say anything further after what Mr. Setchel has said. I was going to say, with respect to Mr. Hickey, what Mr. Setchel has said. Mr. Hickey is not here, and in view of the position he holds as first vice-president I think it would be an insult to him not to elect him, and I think we certainly should vote for Mr. Hickey for president.

The PRESIDENT—I have a little delicacy in talking about this thing. Of

course all these remarks are out of order. But perhaps I might be permitted to get up and say that I do not want to be president of this association and would not take the position. I have a strong appreciation of Mr. Hickey and should vote for Mr. Hickey. It is his due. He has been vice-president of the association for a number of years.

You will prepare your ballots for president.

The balloting was then proceeded with, and Mr. SETCHEL announced that 56 votes had been cast, of which Mr. John Hickey had received 51, and of which 5 were scattering.

The PRESIDENT—I declare Mr. Hickey elected president, and I appoint Messrs. Barnett and Setchel a committee to notify Mr. Hickey. I think it should be done by wire.

Prepare your ballots for vice-president.

Mr. SECHTEL—50 votes have been cast, of which William Garstang has received 42 ; scattering 8.

The PRESIDENT—I declare Mr. Garstang duly elected first vice president for the ensuing year.

Prepare your ballots now for second vice-president.

The balloting for second vice-president was proceeded with.

Mr. SWANSTON—Isn't there a clause in our rules that limits the number of associate members?

Mr. SETCHEL—Fifty votes have been cast for second vice-president, of which R. C. Blackall has received 40 ; scattering 10. (Applause.)

The PRESIDENT—I have the pleasure of announcing to you that you have elected Mr. R. C. Blackall as second vice-president of this association for the ensuing year.

Secretary SINCLAIR—I suggest that a committee be appointed to find Mr. Blackall and bring him in and let us see him in the dignity of his new office.

The PRESIDENT—I will appoint upon that committee, Mr. Fuller and our worthy ex-president, Mr. Briggs.

I want also to say to the committee that is to notify Mr. Hickey of his election as president that they should also notify Mr. William Garstang of his election as first vice-president. I would suggest that the same be done by wire.

Mr. LAUDER—I move that the secretary of the association be instructed to wire Mr. Hickey of the action of this convention to-day and also to express the sympathy of this association with him in his affliction.

The PRESIDENT—It was moved that the committee to notify Messrs. Hickey and Garstang of their election be authorized to send a telegram, drawing upon the secretary for the money necessary to pay for it.

The motion was carried.

The PRESIDENT—You will now prepare your ballot for treasurer.

Mr. LAUDER—To save time and knowing that it would be a unanimous vote I would move that the secretary be authorized to cast the ballot of this association for treasurer.

The motion was carried.

The PRESIDENT—Mr. Secretary, you will prepare the ballot for treasurer for this association for the ensuing year.

The secretary prepared a ballot and deposited it with the tellers.

Mr. SETCHEL—Mr. President, we have received the unanimous vote of this association for O. Stewart as treasurer. (Applause.)

The PRESIDENT—Gentlemen, I have the honor to present to you Mr. O. Stewart whom you have just elected treasurer for the fourth time.

Mr. STEWART—Gentlemen, I thank you for the confidence expressed in me by this unanimous re-election to the important position of treasurer of this honorable body. I accept it, and I will use my utmost endeavors to perform all the duties devolving upon me for the interests of the association. (Applause.)

There were calls for Mr. Blackall.

Mr. BRIGGS—Mr. President, as one of the committee appointed to bring Mr. Blackall before you, I announce that my duty is performed.

The PRESIDENT—Gentlemen, I have the honor of extending my hand to the second vice-president, and I hope everybody in the house will do the same.

Mr. BLACKALL—Mr. President and gentlemen. I appreciate the honor. While I have been very closely identified with the Master Car Builders, nevertheless my heart has been with you in all your meetings. When it was intimated that I might be made a second vice-president, I vanished. However, gentlemen, I will endeavor to do my duty wherever I am placed, (Applause.)

The PRESIDENT—Gentlemen, you will now prepare your ballots for secretary for the ensuing year.

Mr. SWANSTON—I would move, Mr. Chairman, that the president be allowed to cast this ballot.

Mr. O. STEWART put the question and the motion was carried. The president thereupon cast the ballot.

Mr. SETCHEL—Mr. President, I have received the unanimous vote of this association for Angus Sinclair as secretary of this association. (Applause.)

The PRESIDENT—Gentlemen, I have the honor of announcing to you that you have elected by unanimous vote Mr. Sinclair as secretary of this association for the ensuing year.

Secretary SINCLAIR—Mr. President and gentlemen: I am very much gratified at being elected your secretary again. I am proud of the office and proud of the association. I talk and work for the association to the best of my power, in season and sometimes out of season. If I do things out of season it is more through zeal and a desire to promote the interests of the association than anything else; and the cordial way in which our members have accepted the notice of my election is particularly gratifying. I will do my best in the future to promote the interests of the whole of you as I have done in the past. (Applause.)

The PRESIDENT—Gentlemen, I know of no business to come before this association except that of adjourning.

I would like to take this occasion to thank you for the liberal support which you have given me during my occupancy of the chair, and if I have committed any errors, they have been of the head and not of the heart. (Applause.)

Mr. SETCHEL proposed three cheers for Mr. Mackenzie which were heartily given.

Mr. LAUDER—The best presiding officer we ever had.

The PRESIDENT—I thank you again, gentlemen.

I regret very much that Mr. Hickey has not been with us.

I am grateful for your leniency to me, particularly in respect to the noon hour. If the noon hour discussion had been insisted upon I would have had no chance for rest. I am very grateful for the support that you have given me, and the other officers are thankful for all that you have done. If it were not for the continued kind feeling that you exhibited toward me I could not have handled the convention as I did. I may have ruled a little arbitrarily at times perhaps; but as I said before, it was a fault of the head and not of the heart.

On motion of Mr. SPRAGUE the convention then adjourned.

OBITUARY.

JAMES SEDGLEY.

In the death of Mr. James Sedgley, for many years the general master mechanic of the Lake Shore and Michigan Southern Railway, the association loses one of its former well-known officers, and one of its earliest and most highly esteemed members.

After several years of impaired and failing health, he passed away at Washington, D. C., where he was spending the winter, the 12th day of January last.

He continuously served as a member of various committees from the organization of the association until his retirement from business, and his exceptionally good judgment and large experience, acquired during a long life spent in railroad service, made his counsel of great value in the deliberations of the association. For a number of years, 1883 to 1889, he was one of our vice-presidents, and he never failed to take an active part in the annual conventions and the work of the society until failing health compelled him to retire from active service.

James Sedgley was born January 11th, 1824, in Limerick, York county, Maine. He was one of eleven children, and the fifth son of Jotham and Hannah (Alden) Sedgley. His father was of English descent, and his mother, whom Mr. Sedgley much resembled, was a woman of remarkable strength of character, and the great-great-granddaughter of that John and Priscilla Alden whose simple story has been made a part of the history of the early settlement of New England. Descended thus from Puritan stock, Mr. Sedgley inherited and carried through life the distinctive stamp of this peculiar type of character.

Mr. Sedgley's business life began just at the time of the inauguration of the railway industry in America, the wonderful

growth and expansion of which has so completely transformed both the commercial and social life of this country. In 1843, after passing his boyhood life on his father's neatly kept farm, he learned the machinist's trade at Biddeford, Maine, and found in this occupation not only a means of livelihood, but the beginning of a congenial business career. Soon after completing his trade, he went to Lowell, Mass., and with the Locks and Canal Co. of that city he acquired some knowledge of locomotive building, and soon after entered into the employ of the Boston and Maine Railroad Company.

About 1845 he entered into the employ of the Northern (N. H.) Railroad Company, and was stationed at Concord, N. H. In the several changes made in these and the years immediately following, Mr. Sedgley went through an experience not easy to parallel in these busy times. In later life, in contrasting the wonderful growth of railway transportation, from its small beginnings, he used to cite, in illustration of that period of his life when for a short time he was employed by a small New England railroad, when three days in the week he ran a locomotive from one end of the road to the other, and on alternate days he constituted in his own person the entire force of the repair shop, putting the rolling stock in condition for its next day's work.

After two years' experience as a locomotive engineer on the Connecticut and Passumpsic River Railroad in Vermont, Mr. Sedgley returned to Concord in 1847, as foreman in the shops of the Northern Railroad, soon after being promoted to the position of master mechanic. The railroad of which he was in charge was constructed through a hilly country, and owing to the severe winters and the light rolling stock then in general use, it was a difficult one to operate. An old friend, in speaking of this period of Mr. Sedgley's life, said that "No combination of wreck and storm ever daunted his courage, lessened his tireless energy, or clouded his good cheer."

He served as a member of the City Council in Concord, N. H., in 1856, and a representative from that city in the State Legislature in 1857–58.

After more than fifteen years with the Northern Railroad, in 1865 Mr. Sedgley accepted a position as general master mechanic

of the Michigan Southern & Northern 'Indiana Railroad, with headquarters at Adrian, Mich. He entered upon this new position just at the culmination of a long threatened and obstinate strike on the part of the enginemen and firemen of the road, which involved him in difficulties peculiarly harassing, but working in harmony with the other officers of the road, he combated the strike successfully, filling the vacant places with other men, and he was able to demonstrate the principle to which he always adhered, that the managers of a railroad are the ultimate and only authority for the conduct of its affairs.

In 1870, upon the consolidation of the Lake Shore and Michigan Southern Railways, Mr. Sedgley was made general master mechanic of the united lines and removed to Cleveland, Ohio, which position he filled always with eminent satisfaction to the company until failing health compelled him at the close of the year 1883 to lay aside the active duties of his position and seek rest and health in retirement.

During his connection with the latter road, he improved the organization of his departments, and the methods and facilities for its operations; he took especial pride in the extensive shops at Elkhart so well adapted not only for repairs, but for locomotive building, that they were frequently inspected by visitors from our own and other countries. He also introduced many measures for the comfort and improvement of the employes, during his connection with the company, building lodging houses for the men, and providing free instruction in mechanical drawing. He believed a railroad company to be successfully operated, should employ a class of men distinctively reliable and obedient; he gave implicit obedience to his superior officers, and was appreciative of the like quality in the men under his control.

His personal service was rendered with an eye single to the best interests of the corporation by whom he was employed; he gave freely of his time by day or by night and always without the utterance or feeling of complaint. Mr. Sedgely was an excellent controller of the department in which he was engaged in every respect, thoroughly familiar with metals and their uses, prudent in his demands for supplies, careful of their distribution

and use, sagacious in judgment, upright in character, a courteous and Christian gentleman in every department of life.

He was a most devoted church member and a generous supporter of all benevolent adjuncts of church work.

His many personal friends will long cherish the memory of a man whose life throughout was consistent with entire loyalty to the highest principles of manhood. The world was richer for his work and better for the example of his manly life.

His remains lie buried in Blossom Hill Cemetery, Concord, N. H. He is survived by a wife and two daughters, to whom this association extends its deepest sympathy.

GEO. W. STEVENS.

W. F. TURREFF.

William Fleming Turreff was born of Scotch parents at Toronto, Ont., April 20, 1834. He learned the machinist trade in his native town and soon after finishing his apprenticeship he went to Buffalo, N. Y., and worked in a marine engine works. At that time railroad machinery was considered of secondary importance compared with the appliances connected with water transportation ; but it was every year advancing in consequence, and ambitious mechanics began to turn their eyes to railroad machinery, as the coming era in the great problem of transportation.

Mr. Turreff entered railroad service in August, 1853, with the Cleveland & Columbus Railway, as machinist, at Cleveland, O.; May to September, 1863, gang foreman, Bellefontaine & Indianapolis, Galion, O.; September, 1863, to March, 1864, gang foreman, Cleveland & Columbus Railway, Cleveland ; March to August 15, 1864, gang foreman, Wabash & Western Railway, Springfield, Ill.; September 1, 1864, to March, 1865, gang foreman, Cleveland & Pittsburgh Railroad, Cleveland ; March, 1865, to May, 1866, foreman, Cleveland machine shops, same road ; March, 1866, to September, 1874, general foreman, locomotive and car shops, same road, Cleveland ; September, 1874, to 1879, master mechanic and car builder, Cleveland, Tuscarawas Valley & Wheeling Railroad ; 1879 to December 31, 1880, train master, same road, in addition to above duties ; January 1st to March 27, 1881, superintendent, Indianapolis Division, Cleveland, Columbus, Cincinnati & Indianapolis Railroad ; March 27, 1881, to 1890, superintendent motive power, same road ; November, 1890, to January 17, 1892—date of his decease—assistant-superintendent of motive power, New York, Lake Erie & Western Railroad. Owing to the serious illness of Mr. Ross Kells, Mr. Turreff had entire charge of the mechanical department of the whole Erie system six months prior to his decease. Cause of death, pneumonia, after an illness of four days at the Hotel Imperial, New York.

Quiet and unassuming, faithful to every trust, he left a host of real friends. Cheerful and kind to all, he had the advantage

of most men in dealing with those under him, always having a kind word for all ; and his good sense and ability of smoothing down the rough pathways of life, encouraging those that felt aggrieved and binding up the bowed down.

Mr. Turreff leaves a wife and one daughter, who have the sympathy of hosts of friends in their loss. He was a prominent member of the Master Car Builders' and of the Master Mechanics' associations and took a warm interest in the work done by those organizations.

WILLIAM FULLER.

ROSS KELLS.

Ross Kells was born at Steubenville, O., January 20, 1840. He began railroading in 1855 as a brakeman, and shortly afterward became a fireman on the Steubenville & Indiana Railroad, now part of the Pittsburgh, Cincinnati, Chicago & St. Louis Railroad. March 1, 1856, he entered the Steubenville shops of the same company as a machinist apprentice. He was appointed gang foreman in 1860, which position he held until September 15, 1864, when he was appointed night roundhouse foreman. When the shops of the Pittsburgh, Cincinnati & St. Louis Ry., at Dennison, were completed in 1865, he accepted the position of day roundhouse foreman at that place, holding the same until August 1, 1872, when he was made general foreman. July 23, 1875, he was appointed master mechanic of the same shops. September 1, 1882, he was appointed superintendent of motive power of the New York, Chicago & St. Louis Railroad, with headquarters at Cleveland, O. January 1, 1883, he went to Boston, Mass., as superintendent of motive power of the New York & New England Railroad. February 1, 1884, to February 15, 1887, he was superintendent of the Paige Car Wheel Company, at Cleveland, O. February 15, 1887, he received the appointment of assistant superintendent of motive power of the New York, Lake Erie & Western Railroad, in charge of the New York, Pennsylvania & Ohio Railroad, with headquarters at Cleveland, O. November 2, 1888, his jurisdiction was extended over the entire Erie system. January 1, 1889, he was made superintendent of motive power of the N. Y. L. E. & W. Ry., with headquarters at New York. His jurisdiction was extended to the Chicago & Erie, October 1, 1890. He died at Dansville, N. Y., March 10, 1892.

LEROY KELLS.

WILLIAM SMITH.

William Smith, superintendent of motive power and machinery of the Boston and Maine Railroad, died of heart failure at his home in Lawrence, Mass., January 19, 1892. Mr. Smith was born in South Berwick, Maine, October 9, 1827, and at an early age entered the machine shop of the Great Falls Manufacturing Co., at Great Falls, N. H., to learn the machinists' trade. In April, 1849, he became identified with the Boston & Maine Railroad, first as machinist in the engine repair shop at Boston, where he served one year. He next served as locomotive fireman for three months, at the end of which period he was promoted to the position of engineman, where he remained for upward of twenty-three years. He was next made engine dispatcher and after six years' service in that position he was made master mechanic in May, 1879.

When the Boston & Maine leased the Eastern Railroad in December, 1884, he was appointed superintendent of motive power and machinery of the combined roads, which position he held at the time of his decease. He was twice married and with the exception of a widowed sister who made her home with him, leaves no immediate family. He had served as a member of the Common Council and the Board of Aldermen in the City of Lawrence, being president of the Board of Aldermen for three years, and had been in the past actively identified with the fire department of that city. He was a member of the Royal Arcanum and a prominent Mason, a member of the Phœnician Lodge, Mt. Sinai Chapter and Bethany Commandery, all of Lawrence. Mr. Smith had slight advantages of education and was essentially a self-made man. Bereft of his father while a boy of tender years, it fell to his lot to become the mainstay of a large family, and nobly he performed his task. He was plain and blunt of speech, but the rugged exterior covered a generous heart which was ever ready to respond to the appeal of charity. A man of positive ideas, he was a master of his chosen profession, and he will be sadly missed by those with whom he was associated. He became a member of the American Railway Master Mechanics in 1880.

EDWARD E. DAVIS.

SYLVANUS D. BRADLEY.

Sylvanus D. Bradley, master mechanic of the Grand Rapids & Indiana Railroad Co., died of paralysis of the brain at his home at Grand Rapids, Michigan, July 23, 1891. Mr. Bradley was born at Mansfield, Ohio, in 1837, and entered railway service in 1862 as machinist for the Bellefontaine Railroad Co., at Galion, Ohio, remaining there until January, 1865, when he went as machinist to Fort Wayne, Indiana, with the Pittsburgh, Fort Wayne & Chicago Railroad Co., and from November, 1866, to November, 1881, held the position of general foreman at Fort Wayne with the same company.

From January, 1882, until the time of his death he was master mechanic of the Grand Rapids & Indiana Railroad Co., at Grand Rapids, Michigan.

Mr. Bradley was a faithful and conscientious railroad officer, and as a mechanic had few superiors. He was also one of the most charitable of men; a deserving case never failing to elicit his sympathy and attention.

He was a very devoted man to his family, and about a year previous to his own death, he suffered a severe loss in the death of his estimable wife, from which he never fully recovered. He leaves an adopted daughter of his own immediate family to mourn his loss.

JAMES E. KEEGAN,

EDWARD NICHOLS.

Edward Nichols, president of the Brooks Locomotive Works, died at the residence of his mother-in-law, Mrs. H. G. Brooks, in Dunkirk, N. Y., at 4.30 A. M., on Thursday, January 7th, 1892, in the 42d year of his age.

The immediate cause of his demise was pleuro-pneumonia, preceded by a severe cold contracted a short time previous. He had never fully recovered from the shock he received when he passed through the fiery ordeal at the burning of the Leland Hotel in Syracuse, in October, 1890, when he escaped with a broken leg and severe burns.

Mr. Nichols entered the Rensselaer Polytechnic Institute at the age of 16, and upon graduation was employed by the Bethlehem Iron Co., of Bethlehem, Pa., and afterward in the Standard Steel Works of Lewiston, Pa., and also for a time was connected with the Burden Iron Co., of Troy, N. Y., on special service.

After leaving their service he located at Hermitage, Ga., where he operated a charcoal furnace and engaged in mining iron ore. During this period he discovered in that region a deposit of Beauxite which he fully described in a paper presented at a meeting of the Institute of American Mining Engineers, in July, 1887, which we believe is the first record we have of the occurrence of this mineral in the United States in commercial quantity.

In 1885 Mr. Nichols became vice-president and general manager of the Warren Scarf Asphalt Paving Co., New York, with office in Cincinnati, Ohio.

In 1884 Mr. Nichols married Miss Jessie M. Brooks, daughter of the late Horatio G. Brooks. She died about a year after they were married. Their son, who survives both parents, Jesse Brooks Nichols, is being educated under the care and supervision of Mr. Nichols' mother, at Tarrytown, N. Y.

On the death of Mr. H. G. Brooks, the founder of the Brooks Locomotive Works, in 1887, Mr. Nichols succeeded to the presidency of the corporation, and continued as its executive head until his untimely death, displaying in this short time a remarkable business capability.

M. L. HINMAN.

JOSEPH BRADT.

Joseph Bradt, for twenty-two years master mechanic of the New York, Lake Erie & Western Railway, died at Avon, N. Y., July 31, 1891. Mr. Bradt was born at Schenectady, February 13, 1833. After receiving a common school education he learned the trade of machinist. His work with the Erie covered many years, the time being divided between Avon, Buffalo and Rochester. He was twice married, his second wife and two adult children by his first wife surviving him.

Mr. Bradt was extremely popular with the men under his charge and with the officials of the road, and left a large circle of friends to mourn his loss. A. DOLBEER.

O. A. HAYNES.

Orville A. Haynes was born in Coleraine, Mass., on August 31, 1827. At the age of 16 he went to Chicopee, Mass., and worked in a cotton mill at that place for a time. He then went to Ames' Machine Shop, serving his apprenticeship of three years at the trade of machinist. From there he went to Springfield, Mass., and worked in the United States Armory at that place. He then went West, going first to Chicago in 1847, taking a position with the McCormick Reaper Company, where he remained for about a year, and then went to St. Louis, going to work for Gaty, McCune & Company, with whom he remained until May, 1852.

At this time his health failed him, and he went back East, and after a few months' rest, took the position of general foreman in the locomotive works of Blanchard & Kimball, at Springfield, Mass., during which time he was married. In the winter of 1854–55 he assisted in constructing the Providence & Bristol Railroad, and in January, 1856, went to Northern New York, transporting and setting up the engines for the Rome, Watertown & Ogdensburg Railroad, with which road he remained until 1869, and afterward went to Oneida, N. Y., for the Midland Railroad. In 1871 he returned to St. Louis, Mo., as master mechanic of the St. Louis, Iron Mountain & Southern Railway, going to Texas in 1882 as superintendent of machinery for Gould's Southwest system, embracing the St. L. I. M. & S. Ry., T. & P. Ry., I. &. G. N. Ry., and the M. K. & T. Ry., south of Muskogee. In 1885 he came back to St. Louis as general inspector of locomotives, cars and machinery for the Gould system, which position he held until January, 1888, when the office was abolished. He was then agent for the Missouri Car & Foundry Company until January, 1891, at which time the Carondelet Electric Light & Power Company was organized, and he was elected general manager, which position he held up to the time of his death, which occurred at Lebanon, Mo , May 21, 1892.

The funeral took place under the auspices of St. Louis Commandery No. 1 Knights Templars, of which he was an honored member, the remains being laid to rest at Bellefontaine Cemetery and were accompanied by a very large funeral cortege. H. ELLIOT.

WILLIAM WILSON.

Mr. William Wilson, formerly superintendent of machinery of the Chicago & Alton Railroad, at Bloomington, Ill., departed this life at Chicago, Ill., August 10, 1891, after several months suffering from nervous prostration, congestion of the brain being the immediate cause of his death. Mr. Wilson was born in Rochester, N. Y., February 22, 1832, and entered the railway service in 1851, as a machinist, in the employ of the Erie Railroad, at Dunkirk, N. Y., where he remained until 1853. From 1853 to 1854 he was with the Michigan Central Railroad. In 1854 he was on the Galena & Chicago Union Railway, at Chicago, where he remained until the close of the year. From 1854 to 1857, he was on the Michigan Southern & Northern Indiana Railway, at Adrian, Mich. In 1857 he was on the Chicago, Burlington & Quincy Railway, at Galesburg, Ill., where he remained until 1859, leaving the C., B. & Q. Ry. in the latter part of 1859. He returned to the Galena & Chicago Union Railway as general foreman, which position he retained until 1864. In 1865 he was appointed division master mechanic on the C., B. & Q. Ry., and in 1875 became general master mechanic of the same road, at Aurora, Ill. From 1879 to 1880 he was master mechanic of the Wabash, St. Louis & Pacific Railway, at Fort Wayne, Ind. He resigned this position in 1880 to accept the office of superintendent of machinery on the Chicago & Alton Railroad, which he resigned in June, 1889, on account of ill health.

For several years prior to his death, his intimate friends beheld with regret the gradual undermining of his constitution, but with an iron will, which was characteristic of the man, he always presented a cheerful front, and would never speak of his suffering. Shortly after leaving the railway service he lost his wife. This was a severe blow, from which he never rallied, and only survived her ten months. Mr. Wilson was a man of marked qualities of mind and heart. Modest and unassuming in his deportment, kind and condescending in his relations with his subordinates, his dealings always governed by the strictest integrity, he won alike the regard of those who met him in the walks of

business life, and the respect and confidence of those who were employed under him. He possessed mechanical ability of a high order, and may be termed an inventive master mechanic, and he was one of the ablest of this class. As a clear-headed designer of machinery, as a business-like shop superintendent, and as a manager of men, he had few equals.

He leaves three daughters to mourn his loss, to whom we extend the sympathy of this association.

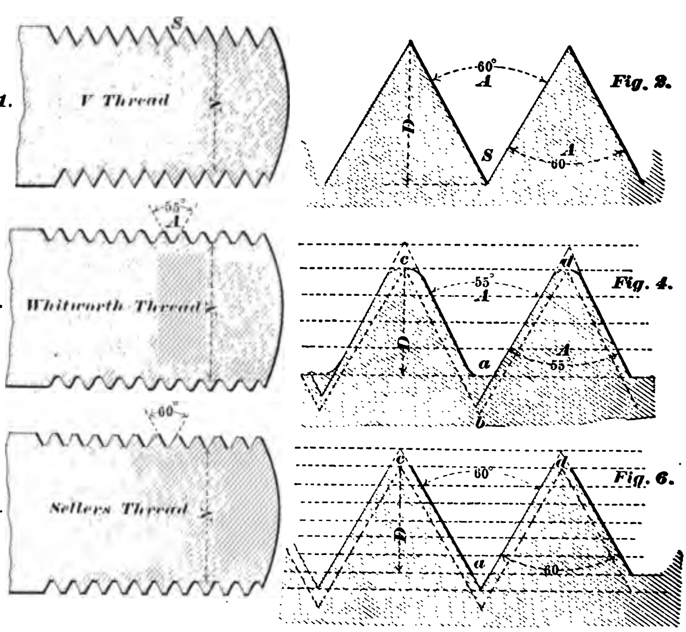
A. W. QUACKENBUSH.

STANDARDS ADOPTED BY THE AMERICAN RAILWAY MASTER MECHANICS' ASSOCIATION.

SCREW THREADS.

At the Third Annual Convention the report of a committee recommending the United States Standard Screw Thread was adopted. Annexed are the forms and dimensions of the threads in question.

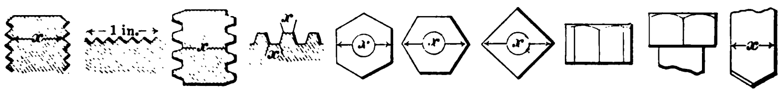
Fig. 1.
Fig. 2.
Fig. 3.
Fig. 4.
Fig. 5.
Fig. 6.



SCREW THREADS. SELLERS' STANDARD.

The association at the Twenty-fifth Annual Convention adopted

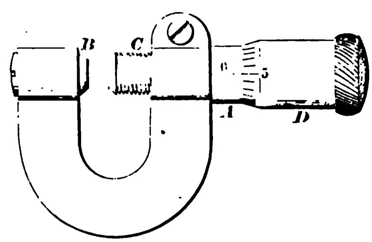
the United States standard sizes of nuts and bolt heads, particulars of which are given below :



Diameter of Screw.	Threads per inch.	Diameter at root of Thread.	Width of flat.	Short diameter of Hexagon or Square.	Long Diameter Hexagon.	Long Diameter Square.	Thickness Nuts.	Thickness Heads.	Tap Drill.
1/4	20	.185	.0062	1/2	37/64	7/10	1/4	1/4	3/16
5/16	18	.240	.0074	19/32	11/16	27/32	5/16	19/64	1/4
3/8	16	.294	.0078	11/16	51/64	63/64	3/8	11/32	5/16
7/16	14	.344	.0089	25/32	29/32	1 7/64	7/16	25/64	23/64
1/2	13	.400	.0096	7/8	1	1 15/64	1/2	7/16	13/32
9/16	12	.454	.0104	31/32	1 1/8	1 23/64	9/16	31/64	15/32
5/8	11	.507	.0113	1 1/16	1 7/32	1 1/2	5/8	17/32	17/32
3/4	10	.620	.0125	1 1/4	1 7/16	1 49/64	3/4	5/8	5/8
7/8	9	.731	.0138	1 7/16	1 21/32	2 1/32	7/8	23/32	3/4
1	8	.837	.0156	1 5/8	1 7/8	2 19/64	1	13/16	27/32
1 1/8	7	.940	.0178	1 13/16	2 3/32	2 9/16	1 1/8	29/32	31/32
1 1/4	7	1.065	.0178	2	2 5/16	2 53/64	1 1/4	1	1 3/32
1 3/8	6	1.160	.0208	2 3/16	2 17/32	3 3/32	1 3/8	1 3/32	1 3/16
1 1/2	6	1.284	.0208	2 3/8	2 3/4	3 23/64	1 1/2	1 3/16	1 9/32
1 5/8	5 1/2	1.389	.0227	2 9/16	2 31/32	3 5/8	1 5/8	1 9/32	1 13/32
1 3/4	5	1.491	.0250	2 3/4	3 3/16	3 57/64	1 3/4	1 3/8	1 1/2
1 7/8	5	1.616	.0250	2 15/16	3 13/32	4 5/32	1 7/8	1 15/32	1 5/8
2	4 1/2	1.712	.0277	3 1/8	3 5/8	4 27/64	2	1 9/16	1 3/4
2 1/4	4 1/2	1.962	.0277	3 1/2	4 1/16	4 61/64	2 1/4	1 3/4	1 31/32
2 1/2	4	2.176	.0312	3 7/8	4 1/2	5 31/64	2 1/2	1 15/16	2 3/16
2 3/4	4	2.426	.0312	4 1/4	4 29/32	6	2 3/4	2 1/8	2 7/16
3	3 1/2	2.629	.0357	4 5/8	5 3/8	6 17/32	3	2 5/16	2 5/8
3 1/4	3 1/2	2.879	.0357	5	5 13/16	7 1/16	3 1/4	2 1/2	2 29/32
3 1/2	3 1/4	3.100	.0384	5 3/8	6 7/64	7 39/64	3 1/2	2 11/16	3 1/32
3 3/4	3	3.317	.0413	5 3/4	6 21/32	8 1/8	3 3/4	2 7/8	3 11/32
4	3	3.567	.0413	6 1/8	7 3/32	8 41/64	4	3 1/16	3 19/32
4 1/4	2 7/8	3.798	.0435	6 1/2	7 9/16	9 3/16	4 1/4	3 1/4	3 13/16
4 1/2	2 3/4	4.028	.0454	6 7/8	7 31/32	9 3/4	4 1/2	3 7/16	4 1/32
4 3/4	2 5/8	4.256	.0476	7 1/4	8 13/32	10 1/4	4 3/4	3 5/8	4 9/32
5	2 1/2	4.480	.0500	7 5/8	8 27/32	10 49/64	5	3 13/16	4 1/2
5 1/4	2 1/2	4.730	.0500	8	9 9/32	11 23/64	5 1/4	4	4 3/4
5 1/2	2 3/8	4.953	.0526	8 3/8	9 23/32	11 7/8	5 1/2	4 3/16	4 31/32
5 3/4	2 3/8	5.203	.0526	8 3/4	10 5/32	12 3/8	5 3/4	4 3/8	5 7/32
6	2 1/4	5.423	.0555	9 1/8	10 19/32	12 15/16	6	4 9/16	5 7/16

Sheet Metal Gauge.

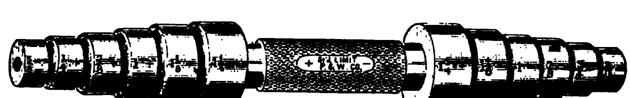
At the Fifteenth Annual Convention the Brown & Sharp micrometer gauge shown below was adopted as standard for the measurement of sheet metal.

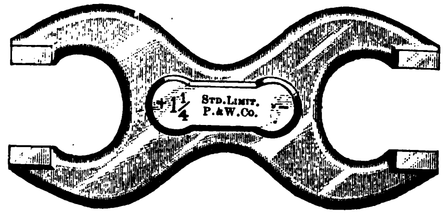


Limit Gauges.

At the Seventeenth Annual Convention the Pratt & Whitney limit gauges for round iron, illustrated on this and following page, were adopted. The sizes are as follows :

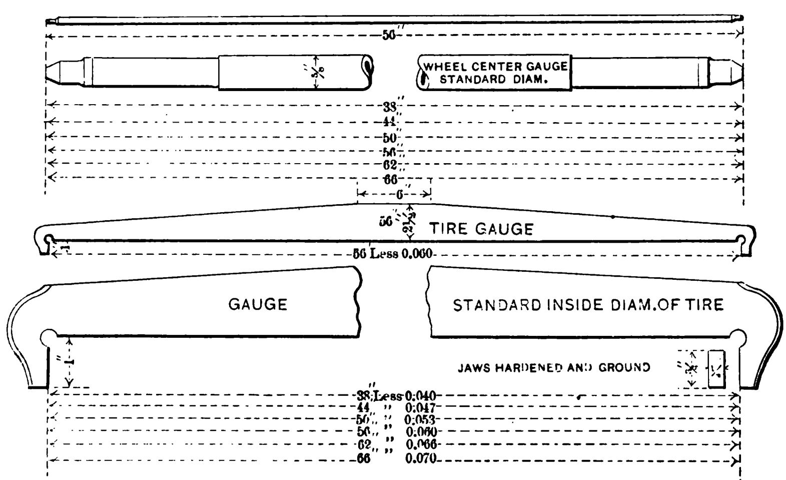
Nominal Diameter. Of Iron. Inches.	Large size. end. Inches.	Small size. -- end. Inches.	Total variation. Inches.
$\frac{1}{4}$	.2550	.2450	.010
$\frac{5}{16}$	.3180	.3070	.011
$\frac{3}{8}$	.3810	.3690	.012
$\frac{7}{16}$	.4440	.4310	.013
$\frac{1}{2}$	.5070	.4930	.014
$\frac{9}{16}$	.5700	.5550	.015
$\frac{5}{8}$	.6330	.6170	.016
$\frac{3}{4}$	.7585	.7415	.017
$\frac{7}{8}$	.8840	.8660	.018
1	1.0095	.9905	.019
$1\frac{1}{8}$	1.1350	1.1150	.020
$1\frac{1}{4}$	1.2605	1.2395	.021





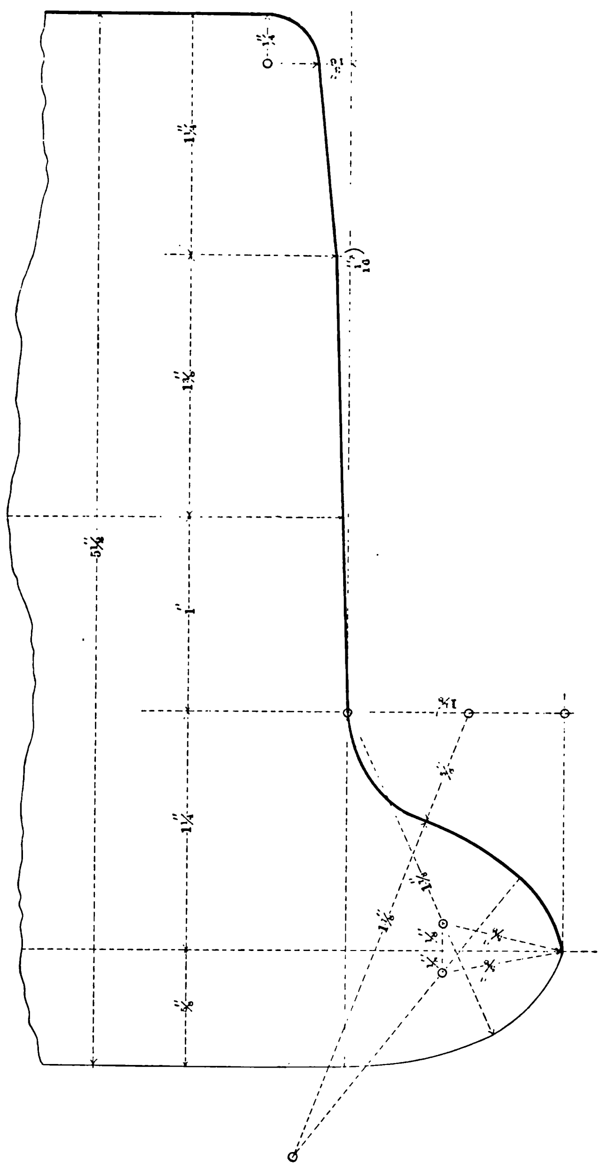
DRIVING WHEEL CENTERS AND SIZES OF TIRES.

At the Nineteenth Annual Convention the report of a committee was adopted which recommended driving-wheel centers to be made 38, 44, 50, 56, 62 or 66 inches diameter. At the Twentieth Annual Convention the recommendations of a committee were adopted making tire gauges manufactured by Messrs. Pratt & Whitney, Hartford, Conn., and here illustrated, standards of the association. The sizes and the allowance for shrinkage are as follows:



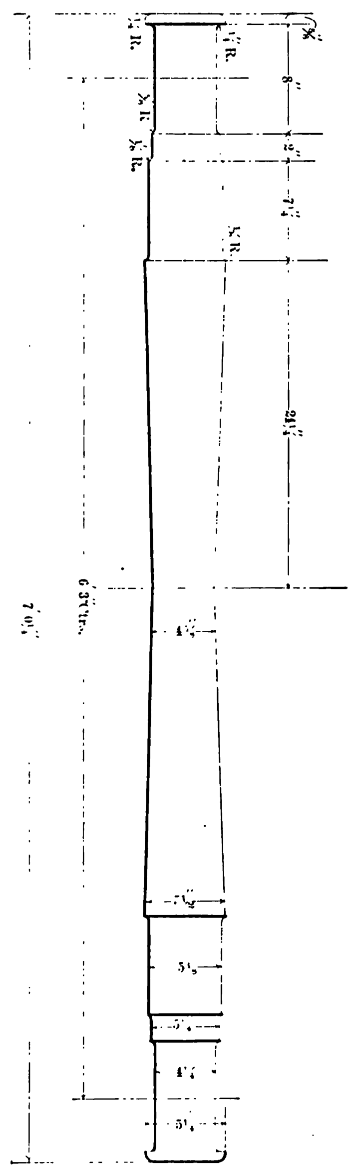
Standard Form of Tire.

At the Twentieth Annual Convention the form of tire shown in the annexed engraving was adopted as standard. Railroad companies ordering tires will save time by specifying this form.



Axle for Heavy Tenders.

The accompanying illustration shows the dimensions of the axle for heavy tenders recommended by a committee of the association.



COMMITTEES FOR CONDUCTING THE BUSINESS FOR THE YEAR 1891-2.

No. 1. Exhaust Pipes, Nozzles and Steam Passages.

C. F. THOMAS,
A. W. GIBBS,
S. HIGGINS,
J. M. WALLIS,
GEO. W. SMITH,
ROBERT QUAYLE,
JOHN Y. SMITH.

No. 2. Standard Tests for Locomotives.

To investigate the practicability of establishing a standard system of tests to demonstrate the fuel and water consumption of locomotives. Also to ascertain the value of the steam engine indicated in locomotive tests.

J. N. LAUDER,
W. J. ROBERTSON,
ALBERT GRIGGS,
JOHN D. CAMPBELL,
F. W. DEAN.

No. 3. Compound Locomotives.

To investigate the relative economy of compound and simple locomotives; also the most valuable form of compound locomotive.

GEORGE GIBBS,
WILLIAM H. LEWIS,
PULASKI LEEDS,
JAMES MEEHAN,
T. W. GENTRY,
A. T. WOODS.

Auxiliary Committee—

S. M. VAUCLAIN, Baldwin Locomotive Works.
REUBEN WELLS, Rogers Locomotive Works.
H. N. SPRAGUE, Porter Locomotive Works.
A. J. PITKIN, Schenectady Locomotive Works
JOSEPH LYTHGOE, Rhode Island Locomotive Works.
F. J. LEIGH, Canadian Locomotive Works.
D. A. WIGHTMAN, Pittsburgh Locomotive Works..
H. TANDY, Brooks Locomotive Works.

No. 4. Tests of Steel and Iron.

To investigate the critical temperature of steel and iron. Also any other questions relating to steel and iron that the committee may consider of value.

WILLIAM SMITH,
J. N. BARR,
A. W. QUACKENBUSH,
P. H. PECK,
D. L. BARNES.

No. 5. Uniform Locomotive Performance Sheets.

To report on the practicability of establishing a system for recording the performance of locomotives that will fairly represent the work done.

GEORGE F. WILSON,
J. S. MCCRUM,
JOHN PLAYER,
JAMES MCNAUGHTON,
JOHN A. HILL.

No. 6. Standard Diameters for Wheel Centers and Tires.

To report on dimensions of wheel-centers for driving wheels larger than the standard; also to investigate the means of securing uniformity in rolled outline of standard tires.

A. E. MITCHELL,
W. C. ENNIS,
THOMAS MILLEN,
C. A. THOMPSON,
L. R. POMEROY.

No. 7. Boiler Attachments.

How can the safety of these be increased and how can the number of holes in boiler be lessened?

JAMES MACBETH,
A. DOLBEER,
J. M. BOON,
W. A. FOSTER,
M. N. FORNEY.

No. 8. Malleable Iron Castings.

To what extent can these be used to take the place of expensive forgings?

R. H. SOULE,
W. GARSTANG,
W. H. THOMAS,
C. H. CORY,
W. D. CROSMAN.

No. 9. Attachments Between Engine and Tender.

Suggest improved form that will prevent the tendency for the tender to mount the foot-plate; also to report on foot-steps and hand-rails.

J. DAVIS BARNETT,
G. W. STEVENS,
C. E. SMART,
W. S. MORRIS,
L. S. RANDOLPH,
L. F. LYNE.

No. 10. Smoke Prevention.

Recommend methods of smoke prevention that will satisfy municipal requirements in cities.

J. N. BARR,
F. MERTSHEIMER,
P. W. GENTRY,
WM. McINTOSH,
W. H. MARSHALL.

No. 11. Tender Frames.

Report on best form of tender and truck frames of wood and iron.

R. C. BLACKALL, E. E. DAVIS,
JOHN MACKENZIE, T. PURVES, JR.,
F. B. MILES.

Obituary Notices.

SUBJECT.	COMMITTEE.
ROSS KELLS,	LEROY KELLS,
WM. F. TURREFF	WM. FULLER,
JOSEPH BRADT	A. DOLBEER,
S. D. BRADLEY	J. E. KEEGAN,
EDWARD NICHOLS	M. L. HINMAN,
WM. SMITH,	E. E. DAVIS,
WM. WILSON	A. QUACKENBUSH,
O. A. HAYNES	H. ELLIOT,
JAMES SEDGLEY	G. A. STEVENS.

On Applications for Associate Membership.

	COMMITTEES.
GEORGE H. BAKER,	J. N. LAUDER, WM. SWANSTON, R. H. BRIGGS.
JOHN H. LEEDS,	O. STEWART, J. D. CAMPBELL, F. M. TWOMBLY.
H. P. ROBINSON,	J. N. BARR, G. F. WILSON, PETER H. PECK.

Committee on Subjects for Investigation.

GEORGE GIBBS, WILLIAM SMITH,
E. M. ROBERTS.

Delegates to American Society of Railroad Superintendents' Convention.

J. N. LAUDER,
JOHN MACKENZIE.

Executive Committee.

JOHN HICKEY, R. C. BLACKALL,
WILLIAM GARSTANG, O. STEWART,
ANGUS SINCLAIR.

NAMES AND ADDRESSES OF MEMBERS.

JOINED.	NAME.	ROAD.	ADDRESS.
1888	Addis, J. W.	Texas & Pacific	Gouldsboro, Ia.
1890	Agnew, J. H.		Allegheny, Pa.
1887	Aldcorn, Thos.	West Shore	New Durham, N. J.
1892	Allen, G. S.	Phil. & Reading	Tamaqua, Pa.
1886	Ames, L.	Beech Creek	Jersey Shore, Pa.
1892	Antz, Oscar		56 Taylor st., Newark, N. J.
1887	Arp, W. C.	P. C. C. & St. L.	Dennison, O.
1890	Atkinson, R.	Canadian Pacific	Montreal, Que.
1887	Augustine, W.	Keokuk & Western	Centerville, Ia.
1886	Austin, W. L.	Baldwin Loco. Works	Philadelphia, Pa.
1889	Ball, A. W.	N. Y. L. E. & W.	Galion, O.
1892	Ball, A. J.	C. S. & Hocking	Columbus, O.
1888	Barnes, J. B.	Wabash	Springfield, Ill.
1892	Barnett, A. R.	Boston & Maine	Boston, Mass.
1877	Barnett, J. Davis	Grand Trunk	Stratford, Ont.
1886	Barnett, T. E.	Canadian Pacific	Vancouver, B. C.
1890	Barr, J. N.	C. M. & St. P.	Milwaukee, Wis.
1890	Barnum, M. K.	Union Pacific	North Platte, Neb.
1889	Battye, John E.	N. & W.	Shenandoah, Va.
1885	Bean, John	C. & Canton	Canton, O.
1889	Bean, S. L.	Northern Pacific	Fargo, N. Dak.
1892	Beattie, A. L.	New Zealand Gov't	Wellington, N. Z.
1885	Beckert, Andrew	Louis. & Nashville	Decatur, Ala.
1892	Benson, A. E.	Ulster & Delaware	Rondout, N. Y.
1891	Berry, J. H.	C. C. C. & St. L.	Delaware, O.
1892	Billingham, Jos.	Gulf, Col. & S. F.	Galveston, Tex.
1879	Bissett, John	W. W. C. & A.	Wilmington, N. C.
1872	Blackall, R. C.	D. & H. Canal Co.	Albany, N. Y.
1883	Blackwell, Charles	Mount Look-out	Cincinnati, O.
1887	Boatman, F. P.	C. N. O. & T. P.	Ludlow, Ky.
1869	Boon, J. M.	West Shore	Frankford, N. Y.
1890	Boyle, Wilson L.	N. Y. C. & H. R.	West Albany, N. Y.
1890	Bradford, J. C.	Rhode Island Loco. Works	Providence, R. I.

JOINED.	NAME.	ROAD.	ADDRESS.
1888	Bradley, W. F.	K. & Michigan	Charleston, W. Va.
1870	Brastow, L. C.	Central of N. Jersey	Ashley, Pa.
1879	Briggs, R. H.	K. M. C. & B	Memphis, Tenn.
1887	Brooke, Geo. B.	St. Paul & Duluth	St. Paul, Minn.
1890	Brown, Angus	Northern Pacific	Livingston, Mont.
1892	Brown, David	D. L. & W.	Scranton, Pa.
1887	Brown, F. R. F.		Toronto, Ont.
1891	Brown, J. L.	Pitts. & Western	Allegheny, Pa.
1891	Brown, W. A.	Atlantic & Danville	Portsmouth, Va.
1882	Brownell, F. G.		Muncie st., Muncie, Ind.
1891	Bruce, Frank.	Great Northern	Barnesville, Minn.
1890	Bruck, Henry T	C. & Penn.	Mt. Savage, Md.
1882	Bryan, H. S.	D. & I. Range	Two Harbors, Minn.
1890	Bryant, J. T.	Rich. Fred. & Potomac	Richmond, Va.
1887	Buchanan, Wm	N. Y. C. & H. R.	New York, N. Y.
1891	Burns, C. H.	Hous. & Tex. Central	Houston, Tex.
1870	Bushnell, R. W.	B. C. R. & N	Cedar Rapids, Ia.
1891	Butler, L. M	N. Y., Prov. & Boston	Providence, R. I.
1890	Butterly, T. E.	Wabash	Moberly, Mo.
1883	Campbell, John	Lehigh Valley	Delano, Pa.
1891	Campbell, John D.	N. Y. Central	West Albany, N. Y.
1889	Carmody, T.	N. Y. P. & O.	Cleveland, O.
1885	Carson, M. T.	Mobile & Ohio	Jackson, Tenn.
1889	Casanave, F. D.	P. Ft. W. & C	Ft. Wayne, Ind.
1890	Casey, J. J.	L. N. O. & Tex	Vicksburg, Miss.
1868	Chapman, N. E.		251 S. 4th st., Philadelphia, Pa.
1878	Chapman, T. L		46 W. 93d st., New York, N. Y.
1870	Clark, David.	Lehigh Valley	Hazelton, Pa.
1886	Clark, Isaac W.	C. F. & Y. V	Fayetteville, N. C.
1877	Clifford, J. G.	L. & Nashville	Mobile, Ala.
1887	Cloud, John W.		Rookery Building, Chicago, Ill.
1891	Cockfield, Wm	Mexican Central	Jimulco, Mex.
1885	Collier, M. L.	Western & Atlantic	Atlantic, Ga.
1891	Collinson, James	Atch., Topeka & S. F.	Fort Madison, Ia.
1890	Conolly, J. J.	D. S. S. & A	Marquette, Mich.
1892	Cooley, M. W.	Southern Pacific	Fresno, Cal.
1890	Cooper, Chas. J	Toledo, Col. & Cin.	Kenton, O.
1879	Cook, John S.	Georgia	Augusta, Ga.
1879	Cooke, Allen		Danville, Ill.
1891	Cooke, W. J.	Ch. & W. Mich.	Muskegon, Mich.
1888	Cory, C. H.	C. H. & D.	Lima, O.
1892	Crawford, S. B.	Balt. & Ohio	Mt. Clare, Balt., Md.
1885	Cromwell, A. J.	Balt. & Ohio	Baltimore, Md.
1883	Cullen, James	N. C. & St. L.	Nashville, Tenn.

JOINED.	NAME.	ROAD.	ADDRESS.
1889	Curran, Peter	N. Y. L. E. & W.	Bradford, Pa.
1872	Cushing G. W.		Am. Steel Wheel Co., Boston, Mass.
1892	Dailey, J. B.	Rio Grande Western	Salt Lake City, Utah.
1888	Dallas, Wilber C.		947 Desoto Street, St. Paul, Minn.
1890	Davies, J. M.	Chateaugay	Lyon Mt., N. Y.
1892	Davis, Ed. E.	Boston & Maine	Boston, Mass.
1886	Davis, Jas. A	N. T. & Q.	Deseronto, Ont.
1891	Deems, J. F.	C. Bur. & Quin.	Ottumwa, Ia.
1892	Dehn, F. H.	Texas Central	Walnut, Tex.
1889	Deibert, F. W.	Ch., M. & St. P.	Portage, Wis.
1892	Derby, Abram	South Florida	Sanford, Fla.
1890	Derby, R.	South Florida	Sanford, Fla.
1887	Dickson, G. L.		Dickson Loco. Works, Scranton, Pa.
1887	Dickson, J. P.		Dickson Loco. Works, Scranton, Pa.
1890	Dolbeer, Alonza	B. R. & Pittsburgh	Rochester, N. Y.
1882	Domville, C. K.	Grand Trunk	Hamilton, Ont.
1892	Dorsey, J. B.	Ohio River	Parkersburg, W. Va.
1883	Downe, George	Government	Sidney, N. S. W.
1890	Downing, T.	El. Jol. & Eastern	Joliet, Ill.
1889	Durrell, D. J.	Illinois Central	Chicago, Ill.
1881	Eastman, A. G.		Sutton, Que.
1868	Eddy, W. H.	Boston & Albany	Springfield, Mass.
1869	Elliott, Henry		East St. Louis, Ill.
1883	Ellis, Matt	C. St. P., M. & O.	St. Paul, Minn.
1881	Ennis, W. C.	N. Y. S. & W.	Wortendyke, N. J.
1892	Esson, R. C.	Southern Pacific	Newark, Cal.
1886	Ettinger, G. T.		New York, N. Y.
1883	Evans, Edward	Balt. O. &. S. Western	Chillicothe, O.
1885	Fenwick, A.	G. B. W. & St. Paul	Green Bay, Wis.
1885	Ferguson, G. A.	Concord & Montreal	Lake Village, N. H.
1889	Ferry, F. J.	Louis., St. Louis & Tex.	Cloverport, Ky.
1874	Finlay, L.		902 West 4th Street, Little Rock, Ark.
1886	Flahaven, W. M.	P. & W.	Allegheny, Pa.
1888	Forsyth, Wm.	C. B. & Q.	Aurora. Ill.
1875	Foster, W. A.		Fall Brook Coal Co., Corning, N. Y.
1890	Foulks, John	T. St. L. & K. C.	Charleston, Ill.
1877	Fowle, I. W.	Colorado Midland	Leadville, Col.
1887	Fraser, T. A.		Wells & French Car Works, Chicago, Ill.
1891	French, R. E.	Southern Pacific	Oakland, Cal.
1890	Fuller, C. E.	N. Y. L. E. & W.	Jersey City, N. J.
1872	Fuller, Wm.		213 Kennard Street, Cleveland, O.

JOINED.	NAME.	ROAD.	ADDRESS.
1891	Galbraith, R. M	St. L. A. & Tex.	Tyler, Tex.
1885	Galloway, A.	T. A. A. & N. H	Owosso, Mich.
1890	Garlock, W. H	S. L. S. & E.	Seattle, Wash.
1883	Garrett, H. D	Pennsylvania	Philadelpia, Pa.
1892	Garrison, C. E	West Shore	E. Buffalo, N. Y.
1887	Garstang, Wm	Ches. & Ohio	Richmond, Va.
1886	Gentry, T. W	Richmond & Danville	Richmond, Va.
1883	George, Nathan M		Danbury, Conn.
1890	Gessler, Wm	C. R. I. & P	Trenton, Mo.
1888	Gibbs, A. W	Richmond & Danville	Atlanta, Ga.
1890	Gibbs, George	C. M. & St. Paul	Milwaukee, Wis.
1892	Giles, C. F.	L. & Nashville	Pensacola, Fla.
1891	Gillis, H. A	N. Y. L. E. & W	Port Jervis, N. Y.
1883	Gilmore, W. L	L. S. & M. S	Elkhart, Ind.
1890	Givan, F. A.	Norfolk & Western	Norfolk, Va.
1891	Glass, Jno. B.	Allegheny Valley	Verona, Pa.
1891	Gleasier, T. W	Mexican Central	Silao, Mex.
1891	Glover, J. B.	Marietta & Nor. Ga.	Marietta, Ga.
1880	Gordon, H. D		Juniata Shops, Altoona, Pa.
1879	Gordon, Jas. T	Concord	Concord, N. H.
1891	Gould, Amos	N. Y. C. & H. R	E. Buffalo, N. Y.
1869	Graham, Chas.	D. L. & Western	Scranton, Pa.
1892	Graham, Chas. Jr	D. L. & Western	Kingston, Pa.
1882	Graham, J. S.	L. S. & M. S.	Cleveland, O.
1892	Gray, Robert W.	Southern Pacific	Tucson, Ariz.
1889	Greatsinger, J. L.	D. & I Range.	Two Harbors, Minn.
1892	Green, Jos. H	R. & Danville	Columbia, S. C.
1891	Griffin, B. F	D. & I Range	Two Harbors, Minn.
1885	Griffith, Fred. B	D. L. & Western	Buffalo, N. Y.
1872	Griggs, Albert		15 Wayland Street, Dorchester, Mass.
1887	Gugel, Daniel M		Macon, Ga.
1880	Hackney, Clem		624 Washington Street, Milwaukee, Wis.
1880	Hackney, George		Chicago, Ill.
1875	Haggett, J. C	D. & A. Valley	Dunkirk, N. Y.
1886	Haggerty, G. A	Canadian Pacific	McAdams Junct., N. B.
1889	Hall, Don Diego	Government Railways	Santiago, Chili.
1883	Hall, J. N		Montgomery, Ala.
1890	Haller, W. J	Ches. & Ohio	Covington, Ky.
1870	Ham, C. T.		Buffalo Steam Gauge Co., Rochester, N. Y.
1891	Hancock, Geo. A	S. A. & A. P	San Antonio, Tex.
1875	Harding, B. R	R. G. R. & A.	Raleigh, N. C.
1888	Harrington, John	Mexican Northern	Escalon, Mex.
1888	Harris, Geo. D	Georgia Southern	Macon, Ga.
1885	Harrison, W. H	Baltimore & Ohio	Newark, O.

JOINED.	NAME.	ROAD.	ADDRESS.
1889..	Haskell, B.	Northern Pacific	Missoula, Mont.
1888..	Hassman, Wm	N. N. & Miss. Val	Lexington, Ky.
1875..	Hatswell, T. J.	F. & P. M	East Saginaw, Mich.
1888..	Hazelton, G. H	R. W. & O	Oswego, N. Y.
1890..	Hazlehurst, G. B	Baltimore & Ohio	Baltimore Md.
1891..	Hedley E. M	Elevated	98th Street, N. Y.
1891..	Hedley, F	Kings Co. Elevated	Brooklyn, N. Y.
1888..	Hemphill, W. J	Jacksonville South E.	Jacksonville, Ill.
1886..	Hendee, A	Westinghouse A. B. Co.	Pittsburgh, Pa.
1892..	Henderson, G. R	Norfolk & Western	Roanoke, Va.
1882..	Henney, J. B		93 Bird Street, Boston, Mass.
1887..	Heintzleman, T. W.	So. Pacific	Sacramento, Cal.
1892..	Herr, Edwin M	Grant Loco. Wks,	Chicago, Ill.
1877..	Hewitt, John		1323 S. Jefferson Ave., St. Louis, Mo.
1883..	Hickey, John	Northern Pacific	St. Paul, Minn.
1890..	Higgins, S	N. Y. P. & O	Cleveland, O.
1887..	Hill, Jas. W	Peoria & Pekin Union.	Peoria, Ill.
1892..	Hill, Rufus	Penna	Pavonia, N. J.
1892..	Hinckley, A. C	St Jo. & Grand Island.	St. Joseph, Mo.
1885..	Hinman, M. L	Brooks Loco. Works,	Dunkirk, N. Y.
1870..	Hodgman, S. A	Lobdell Car Wheel Co.,	Wilmington, Del.
1883..	Hoffecker, W. L	Central of New Jersey.	Elizabethport, N. J.
1885..	Holman, W. L	Pennsylvania	Renova, Pa.
1890..	Homer, John C	Sta. C. Totton Place,	Cincinnati, O.
1892..	Horton, Henry H	Florida Midland	Kissimmee, Fla.
1892..	Howard, C. H	St. Charles Car Works,	St. Charles, Mo.
1890..	Hudson, E. E	C. C. C. & St. Louis	Cleveland, O.
1892..	Hudson, W. H	E. T. Va. & Ga.	Atlanta, Ga.
1890..	Hufsmith, F	T. & G. N	Palestine, Tex.
1890..	Humphrey, A. L.	Colorado Midland	Colorado City, Colo.
1892..	Hunt, G. H	Southern Pacific	Wadsworth, Nev.
1889..	Irby, Chas	K. C. F. S. & M.	West Memphis, Ark.
1888..	Jackson, O. H	C. C. C. & St. L	Brightwood, Ind.
1883.	Jacques, Richard	Hemenway & Brown,	87 Milk St. Boston, Mass.
1892..	Jenks, E. E	Penn. P'k'see & Bost.	Pen Argyle, Pa.
1892..	Jennings, G. W	Mexican Central	City of Mexico, Mex.
1890..	Jennings, Wm	Mexican International.	Piedras Negras, Mex.
1887..	Johns, C. T		Cleveland, O.
1878..	Johnson, J. B	A. Midland	Helena, Ark.
1887..	Johnson, L. R	Canadian Pacific	Vancouver, B. C.
1887..	Johnstone, F. W		City of Mexico.
1888..	Joughins, G. R	Norfolk Southern	Berkeley, Va.

JOINED.	NAME.	ROAD.	ADDRESS.
1892..	Keegan, Jas. E	G. R. & T	Grand Rapids, Mich.
1892..	Keele, Sanford.	F. & P. M	E. Saginaw, Mich.
1887..	Kells, Leroy	P. C. & St. L	Cincinnati, O.
1890..	Keith, J. M	Care of Baldwin Loco. W'ks,	Philadelphia, Pa.
1882..	Kiehner, John I	2341 E. York Street,	Philadelphia, Pa.
1888..	Kiley, M. R	St. Jo. & G. I	St. Joseph, Mo.
1890..	Killen, W. E	Nevada Central	Battle Mt., Nev.
1887..	Kimball, N. S	M. & Northern	Green Bay, Wis.
1868..	Kinsey, J. I	Lehigh Valley	Easton, Pa.
1892..	Kissler, Lewis	D. L. & West.	Syracuse, N. Y.
1890..	Knapp, G	H. & Shen	Shenandoah, Ia.
1891..	Kredell, R. F	Farm. & Powhatan	Chester, Va.
1890..	Kulbaugh, I. N	Baltimore & Ohio	Pittsburgh, Pa.
1891..	Lamby, T. L	T. St. L. & K. C	Delphos, O.
1873..	Lannan, Wm	House of Representatives,	Washington, D. C.
1888..	Lape, C. F	Wabash	Springfield, Ill.
1882..	Lape, J. K		
1870..	Lauder, J. N	Old Colony	Boston, Mass.
1889..	Lavery, W	N. Y. L. E. & W	Susquehanna, Pa.
1891..	Lawler, F. M	C. C. C. & St. Louis	Mattoon, Ill.
1891..	Lawler, T. S	Ch. & Erie	Huntington, Ind.
1870..	Leach, H. L	1 Rollins st.,	Boston, Mass.
1890..	Leach, H. L. Jr	Fitchburg	Keene, N. H.
1892..	Lee, C. W	R. & Danville	Salisbury, N. C.
1883..	Leeds, Pulaski	L. & Nashville	Louisville, Ky.
1888..	Leigh, F. J	Canadian Loco. Works,	Kingston, Ont.
1890..	Leonard, A. G	N. Y. Central	New York City.
1873..	Lewis, W. H	D. L. & Western	Kingsland, N. J.
1890..	Lewis, William H	C. B. & Northern	La Crosse, Wis.
1890..	Lloyd, T. S	Ches. & Ohio	Richmond, Va.
1890..	Logan, P. A	Canada Eastern	Gibson, N. B.
1892..	Lord, E. P	C. C. C. & St. Louis	Indianapolis Ind.
1868..	Losey, Jacob	Steam Forge Co.,	Louisville, Ky.
1890..	Luttgens, H. A	Rogers Loco. Works,	Paterson, N. J.
1890..	Luttrell, J. W	N. N. & Miss. Valley	Paducah, Ky.
1885..	Lythgoe, Joseph	R. I. Loco. Works,	Providence, R. I.
1887..	Macbeth, James	Adirondack & St. Lawrence	Herkimer, N. Y.
1890..	Macfarlane, T. W	Northern Pacific	Mandan, N. Dak.
1886..	Mackenzie, John	N. Y. C. & St. L	Cleveland, O.
1892..	Mackinnon, Geo. S	Can. Pacific	Farnham, Ont.
1878..	Maglenn, James	Carolina Central	Laurenburg, N. C.
1885..	Manly, Basil	A. & N. C	Newberne, Tenn.

JOINED.	NAME.	ROAD.	ADDRESS.
1891	Manuell, Geo.	Mobile & Ohio.	Jackson, Tenn.
1890	Marshall, E. S.		Madison Car Works, Madison, Ill.
1888	Mayer, A. A.	Grand Trunk	Stratford, Ont.
1889	May, Edward	Intercolonial	Moncton, N. B.
1892	McCann, Thos.	Georges Creek & Cum.	Cumberland, Md.
1892	McCarthy, J. C.	N. O. & N. E.	Meridian, Miss.
1891	McClurg, John	C. C. C. & St. L	Urbana, Ill.
1891	McConnell, J. H.	Union Pacific.	Omaha, Neb.
1890	McCormick, J. H.	C. & P. Sound.	Seattle, Wash.
1890	McCreery, Frank.	C. H. & Dayton.	Dayton, O.
1875	McCrum, J. S.	K. C. Ft. S. & G	Kansas City, Mo.
1892	McCuen, J. P	V. S. & P.	Monroe, La.
1892	McGee, F. H.	Central of Georgia	Macon, Ga.
1883	McGrayel, John		Grand Junction, Ia.
1892	McDuff, Allan.	B. C. R. & N.	Cedar Rapids, Ia.
1892	McIlwain, J. D.		Harvey Steel Car Works, Chicago, Ill.
1890	McIntosh, Wm.	Ch. & Northwestern	Winona, Minn.
1891	McKenna, John	I. D. S.	Indianapolis. Ind.
1890	McNaughton, Jas.	Wis. Central	Waukesha, Wis.
1888	McNiven, P. C		Canadian Loco. Works, Kingston, Ont.
1888	Medway, John	Fitchburg	Mechanicsville, N. Y.
1883	Meehan, James	C. N. O. & T. P.	Ludlow, Ky.
1892	Mertsheimer, F.	Union Pacific	Cheyenne, Wyoming.
1887	Michael, J. B.	E. T. V. & Ga.	Knoxville, Tenn.
1883	Middleton, Harvey		Pullman Shops, Pullman, Ill.
1889	Midelton, Thomas	Government Railways	Sydney, N. S. W.
1885	Millen, Thomas	New York City & N.	High Bridge, N. Y.
1889	Miller, E. A.	Ch. & E. Ill.	Danville, Ill.
1890	Miller, Geo. A.	J. T. & K. W.	Palatka, Fla.
1891	Miller, W. H.	C. H. V. & T.	Columbus, O.
1890	Mills, Stott.	Lehigh & Hudson	Warwick, N. Y.
1881	Minshull, E.	N. Y. O. & W.	Middletown, N. Y.
1892	Minto, H. M.	L. & Nashville	Mobile, Ala.
1888	Minton, A. B	Mobile & Ohio	Murphysboro, Ill,
1870	Mitchell, A.	Lehigh Valley	Wilkesbarre, Pa.
1892	Mitchell, A. E	N. Y. L. E. & West.	New York, N. Y.
1890	Monkhouse, H.	C. R. I. & P.	Horton, Kan.
1888	Montgomery, Wm.	Central of New Jersey	Manchester, N. J.
1890	Moore, J. H.	N. Y. P. & O.	Meadville, Pa.
1882	Morrell, J. E.	C. R. I. & P.	Davenport, Ia.
1887	Morris, W. S.	C. & W. Mich	Grand Rapids, Mich.
1890	Morse, F. W.	Wabash	Ft. Wayne, Ind.
1876	Morse, G. F.		Portland Loco. Works, Portland, Me.
1890	Morse, W. M.	T. & O. C. E.	Marietta, O.
1891	Mott, D. G.	Panama	Colon, Colombia.

JOINED.	NAME.	ROAD.	ADDRESS.
1889	Murphy, J. H		
1890	Murphy, P. H.	St. L., A. & T. H.	E. St. Louis, Ill.
1892	Nauffer, John G.	B. O. & S. W.	
1890	Nicholls, J. Mayne	Ferro Caril	Iquique, Chili.
1875	Noble, L. C.	A. French Spring Co.,	Pittsburgh, Pa.
1890	O'Brien, John	Richm'd & Petersburg	Manchester, Va.
1892	O'Brien, Geo. W.	Central of Georgia	Augusta, Ga.
1890	O'Herin, Wm	Mo., Kans. & Tex	Coolidge, Kas.
1883	Olcott, H. P.		Parsons, Kas.
1891	O'Keefe, Geo. H.	Det., Lan. & Northern	Tonia, Mich.
1874	Ortton, John	T. St. L. & K. C.	Delphos, O.
1890	Page, H. D.	Ch. & Northwestern	Baraboo, Wis.
1891	Papineow, F. G.	M. & M. G	Monterey, Mex.
1891	Pattee, J. O.	Great Northern	St. Paul, Minn.
1879	Patterson, J. S.		523 Phœnix Bldg., Chicago, Ill.
1885	Paxson, L. B.	P. & Reading	Reading, Pa.
1891	Paxton, Thos.	A. T. & S. F.	Nickerson, Kas.
1887	Peck, Peter A.	C. W. I. & Balt.	Chicago, Ill.
1890	Petriken, C. L.		Union Iron Works Co., Selma, Ill.
1868	Perry, F. A	Cheshire	Keene, N. H.
1889	Phelan, J. E	Northern Pacific	Dickinson, Dak.
1878	Pilsbury, Amos	Maine Central	Waterville, Me.
1885	Pitkin, A. J	Schenectady Loco. Works,	Schenectady, N. Y.
1874	Place, T. W.	Illinois Central	Waterloo, Ia.
1881	Player, John	A. T. & S. F.	Topeka, Kan.
1882	Porter, Joseph S.	C. S. & C	Sandusky, O.
1891	Prescott, C. H.	Spokane Falls & Nor.	Spokane Falls, Wa.
1873	Prescott, G. H.	T. H. I. & St. L.	Terre Haute, Ind.
1891	Preston, D.	Canadian Pacific	Montreal, Can.
1890	Price, Wm. D.	P. A. & Western	Delphos, O.
1881	Pringle, R. M.		1101 N. Second Street, St. Louis, Mo.
1891	Pullar, John	Atlantic & Pacific	Winslow, Ariz.
1873	Purves, T. B.	Boston & Albany	E. Albany, N. Y.
1890	Purves, Jr., T. B.	Boston & Albany	E. Albany, N. Y.
1892	Putnam, G. V.	F. S. & G	Gloversville, N. Y.
1887	Quackenbush, A. W.	Chicago & Alton	Bloomington, Ill.
1888	Quayle, Robert	M. L. S. & W.	S. Kaukauna, Wis.
1888	Quinn, John A.	C. V. & C.	Mt. Carmel, Ill.
1890	Ramsey, J. C.	Illinois Central	Memphis, Tenn.
1890	Randolph, L. S.	Balt. & Ohio	Baltimore, Md.

JOINED.	NAME.	ROAD.	ADDRESS.
1889	Ransom, T. W.	N. Y. L. E. & W.	Hornellsville, N. Y.
1891	Rearden, Frank	Missouri Pacific.	St. Louis, Mo.
1888	Reed, W. T.	Ch. St. Paul & K. C.	St. Paul, Minn.
1890	Reid, M. M.	Norfolk Southern.	Berkeley, Va.
1890	Reiley, B.	Minn. & St. L.	Minneapolis, Minn.
1890	Remex, B. H. de.	D. & R. G.	Leadville, Colo.
1883	Rennell, Thomas.	Little Rock & M.	Argenta, Ark.
1883	Renshaw, W.	Illinois Central	Chicago, Ill.
1892	Rettew, C. E.	D. & H. C.	Carbondale, Pa.
1887	Reynolds, W. W.	C. St. L. & P.	Columbus, O.
1883	Rhodes, G. W.	C. B. & Q.	Aurora, Ill.
1883	Richardson, E.	S. & Allegheny.	Greenville, Pa.
1883	Richardson, R. M.	Missouri Pacific.	Little Rock, Ark.
1889	Rickard, C. W.	A. T. & S. F.	Raton, N. M.
1890	Riley, G. M. D.	Sav., Fla. & Western.	Savannah, Ga.
1887	Robb, W. D.	L. & Nashville.	Pensacola, Fla.
1882	Roberts, E. M.	E. T. V. & Ga.	Charleston, S. C.
1891	Roberts, Wood.	St. L. I. M. & S.	Little Rock, Ark.
1885	Robertson, W. J.	C. Vermont	St. Albans, Vt.
1890	Robinson, John.	L. S. & M. S.	Buffalo, N. Y.
1891	Rogers, M. J.	Fla. Cent. & Pen.	Fernandina, Fla.
1890	Rommel, Geo.	Wil. & Northern.	Wilmington, Del.
1882	Ross, Geo. B.	Box 326	Buffalo, N. Y.
1892	Rotheram, T. F.	New Zealand Govt.	Wellington, N. Z.
1891	Russell, W. R.	Q. M. & C.	Quebec, Can.
1890	Rutherford, Wm.	Florida Southern.	Palatka, Fla.
1892	Ryan, Pat.	Louis. & Nash.	Russellville, Ky.
1891	Ryan, I. I.	So. Pacific Co.	Houston, Tex.
1891	Ryder, Henry.	Housatonic.	Falls Village, Conn.
1892	Sague, J. E.	Schenectady Loco. Works,	Schenectady, N. Y.
1887	Sample, N. W.	D. & R. G.	Denver, Col.
1883	Sanborn, C. A.		Carondelet, Mo.
1891	Sanborn, J. N.	C. M. & St. P.	Sioux City, Ia.
1890	Savage, R. W.	St. L., Ark. & Tex.	Tyler, Tex.
1879	Schaeffer, Aug.	Maysville Water Works,	Maysville, Ky.
1874	Schlacks, Henry.	Ill. Central.	Chicago, Ill.
1891	Schreiber, P. H.	C. N. O. & T. P.	Chattanooga, Tenn.
1885	Sedgwick, V.	Mexican National.	Box 101, San Luis Potosi, Mex.
1882	Selby, W. H.		Box 1503 Moberly, Randolph Co. Mo.
1869	Setchel, V. H.		Cuba, N. Z.
1890	Seward, J. P.	A. & B. Short Line.	Annapolis, Md.
1892	Shackford, C. E.	Mexican Central.	San Luis Potosi, Mex.
1890	Shafer, J. C.		Box 101, Atlanta, Ga.

JOINED.	NAME.	ROAD.	ADDRESS.
1870	Shaver, D. O	Pennsylvania	Pittsburgh, Pa.
1890	Sheahan, J. F.	Orange Belt	Oakland, Fla.
1891	Sheer, Jas. M	Ohio & Miss.	Washington, Ind.
1890	Sheerer, E. P	Des Moines Union	Des Moines, Ia.
1890	Shields, J. C	Mineral Range	Hancock, Mich.
1890	Silvius, E. T	J. St. A. & H. R	S. Augustine, Fla.
1883	Sinclair, Angus		912 Temple Court, New York, N. Y.
1880	Sitton, B. J	Mid. Belt	Middlesborough, Ky.
1889	Skinner, H. M. C		N. Y. Loco. Works, Rome, N. Y.
1889	Small, H. J	Southern Pacific	Sacramento, Cal.
1887	Small, W. T		St. Paul, Minn.
1886	Smart, C. E	Michigan Central	Jackson, Mich.
1883	Smith, Allison D	Government	New Port, Victoria.
1887	Smith, F. C		Delaware, O.
1890	Smith, Geo. W	A. T. & S. F	Topeka, Kan.
1883	Smith, Howard M		Alexandria, Va.
1892	Smith, John L	N. Y. L. E. & W	Bradford, Pa.
1891	Smith Wm	Ch. & Northwestern	Chicago, Ill.
1869	Smith, W. T	N. News & Miss. Val.	Lexington, Ky.
1891	Soule, R. H.	Norfolk & Western	Roanoke, Va.
1868	Sprague, H. N		Porter Loco. Works, Pittsburgh, Pa.
1886	Stapf, F. M		Mt. Carmel, Ill.
1890	Stamelen, F	Erie & Huron	Chatham, Ont.
1872	Stearns, W. H	Conn River	Springfield, Mass.
1887	Stephens, S. A		Rhode Island Loco. Works, Providence, R.I.
1874	Stevens, Geo. W	L. S. & M. S	Cleveland, O.
1892	Stewart, Andrew F.	Ches. & Ohio	Huntington, W. Va.
1885	Stewart. O	Fitchburg	Charlestown, Mass.
1890	Stillman, H	S. D. & S. Pacific	Dunsmuir, Cal.
1885	Stinard, F. A		143 Park ave, Paterson, N. J.
1883	Stokes, J, W	St. L. & Terre Haute	E. St. L., Ill.
1887	Stone, W. A.	L. E. & St. L	Huntingburg, Ind.
1890	Stout, Henry K	Pennsylvania	Sunbury, Pa.
1875	Strode, James	N. Central	Elmira, N. Y.
1891	Strom, L	Sonora	Guyamas, Mex.
1890	Studer, A. L	C. R. I. &. P. S	Stuart, Ia.
1883	Sullivan, A. W	Illinois Central	Chicago, Ill.
1891	Sullivan, J. J	Louisville Southern	Harrodsburg, Ky.
1891	Summerskill. T. A.	Manitoba & N West	Portage la Prairie, Man.
1892	Sumner, Eben T	Boston & Maine	Boston, Mass.
1892	Sutherland. R. D.	Bost., R. Beach & Lynn.	Boston, Mass.
1868	Swanston, Wm	C. St. L. & P	Indianapolis, Ind.
1883	Tandy, H		Brooks Loco. Works, Dunkirk, N. Y.
1883	Teal, S. A	F. E. & M. V	Missouri Val., Ia.

JOINED.	NAME.	ROAD.	ADDRESS.
1886	Thatcher, Thos	D. L. & W.	Utica, N. Y.
1885	Thomas, C. F	Richmond & Danville	Alexandria, Va.
1891	Thomas, H. T	D. B. C. & A	E. Tawas, Mich.
1883	Thomas, W. H	E. T. V. & Ga	Knoxville, Tenn.
1890	Thomas. W. J	North P. Coast	Sausalite, Cal.
1890	Thompson, C. A	Phila. & Reading	Jersey City, N. J.
1886	Thompson, W. A	M. H. & O	Marquette, Mich.
1883	Thow, W. M	Government	Sydney, N. S. W.
1892	Todd, Louis C	Bost. & Maine	Boston, Mass.
1892	Tomlinson, Jas. G.	Ala. Great Southern	Birmingham, Ala.
1885	Torrence, John	E. T. & H	Evansville, Ind.
1892	Townsend, Jos	Ch. & Alton	Bloomington, Ill.
1801	Traver, W. H	A. T. & S. F	Raton, N. M.
1883	Tregelles, Henry	Norton, Megaw & Co.	Rio de Jan., Brazil.
1892	Tremp, A. E	Ohio, Southern	Springfield, O.
1892	Tresize, Thos	B. & O	Philadelphia, Pa.
1890	Tuggle, S. R	Kentucky Central	Covington, Ky.
1890	Turner, Calvin G	Phil. Wil. & Balt	Wilmington, Del.
1889	Turner. Chas. E	W. N. Y. & Pa	Olean, N. Y.
1886	Turner, J. S	Eames Vacuum Brake Co.	New York City,
1890	Turner, L. H	Pitt. & L. Erie	Chartiers, Pa.
1886	Twombly, A. W	Old Colony	Taunton, Mass.
1883	Twombly, Fred. M	Old Colony	Boston, Mass.
1880	Twomblv, T. B		Chicago, Ill.
1890	Tyrrell, Thos. H	S. I. R. T	Whitehall st., N. Y.
1887	Tynan, F. F	Ferro Carriles Unidos de la Haoana	Habana, Cuba.
1885	Ulmo, H. A	C. & Savannah	Savannah, Ga.
1872	Underhill, A. B	B. & Albany	Sprngfield, Mass.
1889	Vail, A	W. N. Y. & Pa	Buffalo, N. Y.
1890	Van Brunt, G. E	Penn. & Northwestern	Bellwood, Pa.
1891	Vauclain, Samuel M.	Baldwin Loco. Works	Philadelphia, Pa.
1892	Vogt, Axel	Pennsylvania	Altoona, Pa.
1889	Voss, Wm	Barney & Smith Car Works	Dayton, O.
1892	Wade, R. D	R. & Danville	Atlanta, Ga.
1883	Wakefield, S. W	C. R. I. & P	Keokuk, Ia.
1892	Waitt, A. M	L. S & M. S.	Cleveland, O.
1890	Walden, W. A	Richmond & Danville	Atlanta, Ga.
1886	Walker, C. W	S. & Roanoke	Portsmouth, Va.
1888	Wall, E. W	P. C. & St. L	Columbus, O.
1891	Wallace, Andrew	Ariz. & N. M	Clifton, Ariz.
1887	Wallis, Herbert	Grand Trunk	Montreal, Can.

ŦED.	NAME.	ROAD.	ADDRESS.
1	Wallis, J. M	Pennsylvania	Altoona, Pa.
8	Wallis, Philip	Norfolk & Western	Roanoke, Va.
4	Walsh, Thomas	L. & Nashville	Howell, Ind.
2	Walsh, Thomas	C. N. O. & T. P	Somerset, Ky.
6	Wanklyn, F. L	Grand Trunk	Montreal, Can.
2	Warburton, Chas. H	Cleve. Lor. & Wheeling	Lorain, O.
7	Ward, C. F	Duluth & Winnipeg	Duluth, Minn.
2	Warner, S. H	Nor. Pacific	Tacoma, Wash.
3	Warren, Beriah	T. P. & W	Peoria, Ill.
2	Warren, W. B		2808 Lafayette Avenue, St. Louis, Mo.
0	Warwick, T. F	C. of Ga	Augusta, Ga.
3	Watts, Amos H	C. J. & M	Marshall, Mich.
7	Webb, F. W	L. & N. W	Crewe, England.
0	Webb, M. S	M. & Phœnix	Phœnix, Ariz.
6	Weisgerber, E. L	B. & Ohio	Newark, O.
8	Wells, Reuben	Rogers Loco. Works	Paterson, N. J.
0	West, G. W	N. Y., O. & Western	Middletown, N. Y.
5	Wheeler, M. C	Central Iowa	Marshalltown, Ia.
5	White, A. M	Schenectady Loco. Works	Schenectady, N. Y.
0	White, E. P	C. N. & E	Cadillas, Mich.
5	Whitlock, Joseph	N. H. & D	Ansonia, Conn.
9	Whitney, H. A	Intercolonial	Moncton, N. B.
0	Whittington, E. J		Slater, Mo.
4	Wightman, D. A	Pittsburgh Loco. Works	Allegheny, Pa.
1	Wilcox, W. J	C. C. C	Blacksburg, S. C.
5	Williams, C. G	C. of N. J	Communipaw, N. J.
1	Williams, E. A	M. St. P., S. S. & M	Minneapolis, Minn.
5	Williams, R.	N. Y. Loco. Works	Rome, N. Y.
0	Wilson, D. Ellis	Nitrate	Pisagua, Chili.
7	Wilson, G. F	C. R. I. & P	Chicago, Ill.
0	Wilson, John		1802 Ohio Street, Omaha, Neb.
7	Winslow, J. M.	Todd Mach Co.	Tacoma, Wash.
0	Wyman, Jeffries	B. & Mo. River	Alliance, Neb.

ASSOCIATE MEMBERS.

JOINED.	NAME.	ADDRESS.
1888	Barnes, D. L.	Rookery Building, Chicago, Ill.
1890	Crosman, W. D	Rookery Building, Chicago, Ill.
1883	Dean, F. W.	55 State st., Boston, Mass.
1871	Forney, M. N	17 E. 38th st., New York City.
1880	Gordon, Alex	Niles Tool Works, Hamilton, O.
1889	Hill, John A.	912 Temple court, New York City.
1881	Hill, John W.	Glenn Building, Cincinnati, O.
1881	Lyne, L. F.	307 Grove st., Jersey City, N. J.
1891	Marshall, W. H	Rookery Building, Chicago, Ill.
1871	Miles, F. B.	Bement & Miles, Philadelphia, Pa.
1889	Pomeroy, L. R.	29 Broadway, New York City.
1886	Shaw, Thomas	915 Ridge st., Philadelphia, Pa.
1889	Smith, John Y.	Doylestown, Pa.
1882	Smith, W. A.	Rookery Building. Chicago, Ill.
1871	Wheelock, Jerome	25 Elizabeth st., Worcester, Mass.
1891	Woods, A. T.	Washington University, St. Louis, Mo.

HONORARY MEMBERS.

JOINED.	NAME.	ROAD.	ADDRESS.
1870	Black, John		Lima, O.
1869	Coolidge, G. A		Charlestown, Mass.
1870	Cooper, Chas. J		4644 State st., Chicago, Ill.
1870	Divine, J. F.	W. & Weldon	Wilmington, N. C.
1868	Dripps, Isaac		345 Walnut st., Philadelphia, Pa.
1868	Eddy, Wilson		Springfield, Mass.
1872	Foss, J. M	Central Vermont	St. Albans, Vt.
1874	Jeffery, E. T.	Denver & Rio Grande	Denver, Col.
1868	Johann, Jacob		608 Phœnix Building, Chicago, Ill.
1872	Peddle, C. R		Terre Haute, Ind.
1868	Mulligan, J.	Conn. River	Springfield, Mass.
1874	Perrin, P. J		Taunton, Mass.
1872	Philbric, J. W		Waterville, Me.
1869	Richards, Geo		14 Auburn st., Roxbury, Mass.
1870	Robinson, W. A		Hamilton, Ont.
1869	Sellers, Morris		Phœnix Building, Chicago, Ill.
1888	Sheppard, F. L.	Pennsylvania	Altoona, Pa.
1869	Thompson, John		137 Webster st., E. Boston, Mass.
1870	Towne, H. A.		236 First ave., Minneapolis, Minn.
1869	White, J. L.		Danville, Ill.
1870	Williams, E. H.		Baldwin Loco. Works, Philadelphia, Pa.

CONSTITUTION AND BY-LAWS.

ARTICLE I.

NAME.

The name of this association shall be the AMERICAN RAILWAY MASTER MECHANICS' ASSOCIATION.

ARTICLE II.

OBJECTS OF ASSOCIATION.

The objects of this association shall be the advancement of knowledge concerning the principles, construction, repair and service of the rolling-stock of railroads, by discussions in common, the exchange of information, and investigations and reports of the experience of its members; and to provide an organization through which the members may agree upon such joint action as may be required to give the greatest efficiency to the equipment of railroads which is intrusted to their care.

ARTICLE III.

MEMBERSHIP.

SECTION 1. The following persons may become active members of the association, on being recommended by two members in good standing, signing an application for membership and agreement to conform to the requirements of the Constitution and By-Laws, or authorizing the Secretary to sign the Constitution for them:

(1.) Those above the rank of general foremen, having charge of the design, construction or repair of railway rolling stock.

(2.) General foremen, if their names are presented by their superior officers.

(3.) Two representatives from each locomotive and car building works.

SEC. 2. Civil and mechanical engineers, or other persons having such a knowledge of science or practical experience in matters pertaining to the construction of rolling-stock as would be of special value to the association or railroad companies, may become associate members on being recommended by three active members. The name of such candidate shall then be referred to a committee, to be appointed by the President, which shall investigate the fitness of the candidate and report to the Executive Committee of the association at the next annual meeting. If the report be unanimous in favor of the candidate the name shall be submitted to ballot, and five dissenting votes shall reject. The number of associate members shall not exceed twenty, and they shall be entitled to all the privileges of active members, excepting that of voting.

SEC. 3. All members of the association excepting as hereafter provided, shall be subject to the payment of such annual dues as it may be necessary to assess for the purpose of defraying the expenses of the association, provided that no assessment shall exceed five dollars a year.

Such dues shall be payable when the amount thereof is announced by the President, at each annual meeting. Any member who shall be two years in arrears for annual dues, shall be notified of the fact, and if the arrears are not paid within three months after such notification, his name shall be taken from the roll and he be duly notified of the same by the Secretary.

SEC. 4. Any person who has been or may be duly qualified as a member of this association will remain such until his resignation is voluntarily tendered, or he becomes disqualified by the terms of this Constitution. Members whose names have been dropped for non-payment of dues may be restored to membership by the unanimous consent of the Executive Committee on the payment of all back dues.

SEC. 5. Members of the association who have been in good standing for not less than five years, and who through age or other cause cease to be actively engaged in the mechanical department of railway service, may, upon the unanimous vote of the members present at the annual meeting, be elected Honorary

Members. The dues of the Honorary Members shall be remitted, and they shall have all the privileges of active members, except that of voting.

SEC. 6. Any member who, during the meetings of the association, shall be guilty of dishonorable conduct which is disgraceful to a railroad officer and a member of the association, or shall refuse to obey the chairman when called to order, may be expelled by a two-thirds affirmative vote at any regular meeting of the association held within one year from the date of the offense.

ARTICLE IV.

OFFICERS.

SEC. 1. The officers of the association shall be a President, a First Vice-President, a Second Vice-President, a Treasurer and a Secretary, and they shall constitute the Executive Committee.

ARTICLE V.

DUTIES OF OFFICERS.

SEC. 1. It shall be the duty of the President to preside at all the meetings of the association, appoint all committees—designating the chairman, and approve all bills against the association for payment by the Treasurer.

SEC. 2. It shall be the duty of the Vice-Presidents, according to rank, to perform the duties of the President in his absence from the meetings of the association.

SEC. 3. In case of the absence of both President and Vice-Presidents, the members present shall elect a President *pro tempore*.

SEC. 4. It shall be the duty of the Secretary to keep a full and correct record of all transactions at the meetings of the association ; to keep a record of the names and places of residence of all members, and the name of the railway they each represent ; to certify to the persons who are eligible as candidates for the association's scholarships at the Stevens Institute of Technology ; to receive and keep an account of all money paid to the association and deliver the same to the Treasurer, taking his receipt for the amount ; to receive from the Treasurer all paid bills, giving him a receipted statement of the same.

SEC. 5. It shall be the duty of the Treasurer to receive all money from the Secretary belonging to the association; to receive all bills and pay the same, after having approval of the President; to deliver all bills paid to the Secretary at the close of each meeting, taking a receipted statement of the same and to keep an accurate book account of all transactions pertaining to his office.

ARTICLE VI.

EXECUTIVE COMMITTEE.

SEC. 1. The Executive Committee shall exercise a general supervision over the interests and affairs of the association, recommend the amount of the annual assessment, to call, to prepare for, and to conduct, general conventions, and to make all necessary purchases, expenditures and contracts required to conduct the current business of the association, but shall have no power to make the association liable for any debt to an amount beyond that which at the time of contracting the same shall be in the Treasurer's hands in cash, but not subject to prior liabilities. All expenditures for special purposes shall only be made by appropriations acted upon by the association at a regular meeting.

SEC. 2. The Executive Committee shall receive, examine and approve before public reading, all communications, papers and reports on all mechanical and scientific matters; they shall decide what portion of the reports, papers and drawings shall be submitted to each convention and what portion shall be printed in the annual report.

SEC. 3. Three members shall constitute a quorum for the transaction of business.

SEC. 4. The Executive Committee shall form with a Committee of the Master Car Builders' Association a Joint Committee to decide on the place of meeting for the Annual Convention.

ARTICLE VII.

ASSOCIATION SCHOLARSHIPS.

It shall be the duty of the Secretary to issue a circular annually intimating the date and place when and where candidates may

e examined for the scholarships of the association in the Stevens
nstitute of Technology, Hoboken, N. J.

Acceptable candidates for the scholarships are the sons of nembers of the association in good standing, the sons of hon- rary members and sons of deceased active or honorary members vho may have died while in good standing. Candidates for these cholarships shall apply to the Secretary of this association, and f found eligible shall be given a certificate to that effect for pre- entation to the school authorities. This will entitle the candi- ate to attend the preliminary examination. If more than one andidate passes the preliminary examination, the applicant pass- ng the highest examination shall be entitled to the scholarship, he school authorities settling the question.

The candidates for these scholarships must have at least one ear's experience in some recognized machine shop. The success- ul candidate shall also be required to take the course of mechani- al engineering.

ARTICLE VIII.

ELECTION OF OFFICERS.

SEC. 1. The officers of the association shall be elected by allot separately without nomination at the regular meeting of he association, held in June of each year. A majority of all otes cast shall be necessary to an election, and elections shall not e postponed.

SEC. 2. Two tellers shall be appointed by the President to onduct the election and report the result.

ARTICLE IX.

AUDITING COMMITTEE.

SEC. 1. At the first session of the annual meeting an Audit- ng Committee, consisting of three members not officers of the ssociation, to be nominated by any member who does not hold ffice, shall be elected in the same way as officers are voted for. This Auditing Committee shall examine the accounts and vouch- rs of the Treasurer and certify whether they have been found cor- ect or not. After the performance of this duty they shall be lischarged by the acceptance of their report by the association.

COMMITTEE ON SUBJECTS FOR INVESTIGATION AND DISCUSSION.

SEC. 2. At each annual meeting the President shall appoint a committee whose duty it shall be to report at the next annual meeting subjects for investigation and discussion, and if the subjects are approved by the association the President, as hereinafter provided, shall appoint committees to report on them. It shall also be the duty of the committee to receive from members questions for discussion during the time set apart for that purpose. This committee shall determine whether such questions are suitable ones for discussion, and if so, they shall so report them to the association.

COMMITTEES ON INVESTIGATION.

SEC. 3. When the Committee on Subjects has reported, and the association approved of subjects for investigation, the President shall appoint special committees to investigate and report on them, and may authorize and appoint a *special* committee to investigate and report on any subject which a majority of the members present may approve.

ARTICLE X.

AMENDMENTS.

SEC. 1. This Constitution may be amended at any regular meeting by a two-third vote of the members present, provided that written notice of the proposed amendments has been given at a previous meeting at least six months before.

BY-LAWS.

TIME OF MEETING.

I. The regular meeting of the association shall be held annually on the Monday after the second Wednesday in June.

HOURS OF SESSION.

II. The regular hours of session shall be from nine o'clock A. M. to two o'clock P. M.

PLACE OF MEETING.

III. Places for holding the Annual Convention shall be selected by a joint committee composed of the President, two Vice-Presidents, Secretary and Treasurer of this association, and the President, three Vice-Presidents and Secretary of the Master Car Builders' Association. This joint committee shall meet within six months after the convention and decide upon a place of meeting, the place receiving the largest number of votes to be selected.

QUORUM.

IV. At any regular meeting of the association, fifteen or more members entitled to vote shall constitute a quorum.

ORDER OF BUSINESS.

V. The business of the meetings of this association shall, unless otherwise ordered by a vote, proceed in the following order:

1st. Opening prayer.
2d. Address by the President.
3d. Calling the roll.
4th. Acting on the minutes of the last meeting.
5th. Reports of Secretary and Treasurer.
6th. Assessment and announcement of annual dues.
7th. Election of Auditing Committee.

8th. Unfinished business.
9th. New businesss.
10th. Reports of committees.
11th. Reading of papers and discussion of questions propounded by members.
12th. Routine and miscellaneous business.
13th. Election of officers.
14th. Adjournment.

QUESTIONS FOR DISCUSSION, SPECIAL ORDER OF.

VI. Unless otherwise ordered, the discussion of questions proposed by members shall be the special order from 12 o'clock M. to 1 P. M. of each day of the annual meeting.

DECISIONS.

VII. The votes of a majority of the members shall be required to decide any question, motion or resolution which shall come before the association, unless otherwise provided.

DISCUSSIONS.

VIII. No patentees or their agents shall be admitted in the meetings of the association for the purpose of advocating the claims of any patent or patentee, unless by unanimous consent.

IX. No member shall speak more than twice in the discussion of any question until all the other members who want to speak, and have not been heard, have spoken.

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Report of the Proceedings

OF THE

TWENTY-SIXTH ANNUAL CONVENTION

OF THE

AMERICAN RAILWAY
MASTER MECHANICS' ASSOCIATION

(INCORPORATED),

HELD AT

LAKEWOOD, N. Y.,

JUNE 19, 20 AND 21, 1893.

EDITED BY
ANGUS SINCLAIR, SECRETARY.

NEW YORK:
DE LEEUW, OPPENHEIMER & CO.

1893.

American Railway Master Mechanics' Association

(INCORPORATED).

OFFICERS FOR 1893-1894.

PRESIDENT,

JOHN HICKEY,

St. Paul, Minn.

FIRST VICE-PRESIDENT,

WILLIAM GARSTANG,

Indianapolis, Ind.

SECOND VICE-PRESIDENT,

R. C. BLACKALL,

Albany, N. Y.

TREASURER,

O. STEWART,

Charlestown, Mass.

SECRETARY,

ANGUS SINCLAIR,

New York.

Proceedings.

PRELIMINARY.

The Twenty-sixth Annual Convention of the American Railway Master Mechanics' Association was called to order at 9:30 A. M., at Lakewood, N. Y., by President Hickey.

Prayer was offered by Mr. George Royal.

The address of President Hickey was then presented, as follows:

PRESIDENT'S ADDRESS.

GENTLEMEN OF THE AMERICAN RAILWAY MASTER MECHANICS' ASSOCIATION: It is with much pride and no little pleasure that I appear before you this morning to salute you and extend to you a hearty welcome to this Convention, the twenty-sixth in the annals of the association.

At the threshold of this address allow me to express the sincere hope that your stay in this beautiful and well-selected spot will not only reach the full measure of social enjoyment, but that the practical work of this Convention will produce results as gratifying to the promoters of mechanical progress, will display as much zeal and devotion to the great interests which we are representing, and will be as earnest in its efforts to develop appliances for the safety, the convenience and the comfort of the traveling public as any that have preceded it. It is particularly gratifying to announce that our association is in an excellent condition of growth and prosperity. Our membership is steadily increasing with men of a high order of thought and ability. The influence and work of our association is recognized and supported by the highest and ablest railroad officers on this continent and the conclusions of our committees of record are regarded as authority by the deepest mechanical thinkers of all progressive nations.

While we take much pleasure, however, in remembering the good work of this association in the past, it is well to keep in mind that we are in the midst of a most enlightened and progress-

ive age, and that our work must keep pace and be in harmony with the surroundings of advancement, and that we must awake not only to increased activity in dealing with new questions, but must deal with older ones from an advanced standpoint.

I venture the assertion that every member of the association is confronted to a greater or lesser degree with the question of labor.

The situation of the labor problem to-day is not only causing more general uneasiness to the corporations in whose interest our labors are directed, but is the source of considerable anxiety to the essential principles underlying national property.

While it is true that members of this Convention have to deal with but a moderate proportion of those who make up the rank and file of the laboring classes, it is also true that those comprising that proportion are to a large degree the guiding element. It will therefore be reasonable to assume that, when dealing in our official capacity with this question, we are either laying the foundation of peace and harmony with the working people or sowing the seed of civil strife and disorder. It seems entirely proper that the members of this association, both individually and collectively, use all reasonable efforts towards harmonizing a situation of circumstances fraught with so much interest to all.

Public sentiment, if not legislation, guarantees equal rights to the masses. The march of civilization is onward and upward. All who are placed in authority should be considerate of the rights and welfare of their employés. A desire for betterment in the situation and surroundings of the workingman is a natural and human aspiration. To those at least who have been raised and educated among us these conditions seem to be an inherited right.

While business interests cannot possibly at all times comply with the demands and conditions of labor exponents, their requests should always be met and treated in a friendly spirit, and be considered and decided from the position of justice and fair play.

An arrogant manner and impatient consideration in dealing with our employés has too often been followed by unceasing annoyance, disquietude and unsatisfactory service, while honest recognition of reasonable requests has solved many a labor difficulty and prevented much lawless strife.

Tyrannical and arbitrary expressions of power have driven

thousands of workmen to seek revenge in protective organizations, and we have many times condemned arbitrary acts of their champions when probably ourselves have laid the foundations.

No better plans to nullify the teachings of the labor demagogue can be adopted than to meet reasonable demands of the workingmen in the spirit of honesty, candor and fairness, and by advice and action to make them feel that labor well performed is appreciated, and that they will be protected against injustice (which is usually the result of hasty decision) and that faithfulness to duty means continued employment, promotion and protection to themselves and families.

A little reflection will show that an immense forward movement of late years has taken place in the handling and construction of our locomotives, and it will not be exceeding the limits of reasonable modesty in claiming for this association the credit of this development, but in the advanced and progressing currents of time further economy in the expense of operating seems absolutely necessary.

A majority of the largest roads throughout the country, show an operating expense of from 22 to 25 cents per locomotive mile run. About 50 per cent. of this amount is chargeable to fuel consumed in generating power.

Under the ordinary conditions of operating simple engines, we are exhausting to the atmosphere steam containing nearly 50 per cent. of its original value. To obviate this waste of power, various modifications of the valve motion of simple engines have been attempted and tested, but with little, if any, ultimate success.

Much of this waste of power is undoubtedly due, not to the valve motion, when its functions are properly performed, but it is the effect of cause which makes necessary a violent exhaust for the purpose of creating a blast on the fire equal in intensity to the stress of the duty performed.

The point is to eliminate the necessity of this rapid and continuous production of a given amount of excessive heat in a given time without detracting from the hauling efficiency of the locomotive.

Plainly, boilers of a larger capacity than are generally used, containing an increased amount of heating surface, possessing the highest facilities for proper combustion, thus reducing the neces-

sity of a high velocity of the heated currents, must be followed by the most satisfactory results in permitting a larger percentage of the generated heat being imparted to the water, and proportionately reducing the necessity of intensified blast.

Another means of attempting to utilize a higher percentage of the heat and power produced is the introduction of the compound principle in locomotives.

A superficial view of the principles of compounding properly applied would appear to leave little, if any, doubt of its success.

Additional machinery, however, involving an increased number of parts, enhancing the first cost and of necessity adding to the cost of maintenance, are essential questions when considering the policy of the introduction of compound locomotives.

However, experience in practical tests with the compound engine, particularly where the dimensions were adapted closely to the work to be performed, has been so satisfactory and so productive of expected results, that a continuance of these principles, as a matter of economy, is worthy of the highest consideration.

From information at hand on this subject, the performance of the compound has compared unfavorably with the simple engine only where the dimensions of the former were not as properly adapted to the conditions of the service as the latter.

I have in mind many reports of comparative tests between simple and compound engines, showing enormous gains on the side of the latter. Where these conditions exist, it may be well to suspect that the excessive economy shown is only apparent, and may be due, not so much to the compound principle as to the unprofitable performance of the simple engine, because of its improperly proportioned parts, or its incomplete condition.

Highly drawn service tests between simple and compound locomotives are not always commendable, because the usual conditions under which the tests are conducted are often so widely different from those obtained in ordinary service, that results thus procured should hardly be regarded as conclusive.

Comparative tests can be obtained with a much greater degree of profit by placing the engines in regular and parallel service extending over a period of several months, basing their performance on the tonnage hauled, thus demonstrating not alone the fuel-

saving properties, but establishing to a certainty their relative costs of maintenance.

The cost of repairs in maintenance of locomotives is an expense of much importance, the average of the largest roads reaching nearly 4¾ cents per engine mile.

The maintenance of boilers contributes largely to this account, and it appears to me to be one of the most important duties of this association to prosecute investigation to the end of obtaining the most durable material for boiler construction, and also the most durable coupled with the most capable of performing the necessary functions of the firebox plate.

In this same connection, sufficient water space for free circulation between the inner and outer sheets of firebox, and size and material for stay-bolts, should receive more than a passing notice.

The manner of handling boiler plate during boiler construction is also deserving of special attention.

I may be pardoned if I remind the association of the necessity of increased bearing surfaces in all parts of machinery subject to wear from friction.

With increased bearing surfaces we obtain a decreased pressure per unit of contact, thus insuring more perfect lubrication and lessening the cost of maintenance by reduced wear.

The bearing surfaces of crank-pins, eccentrics, links, guides, etc., can be enlarged from 30 to 40 per cent. on present practice with much benefit.

Eliminating straps, keys, and bolts in all connecting and parallel rods, will be found to result in much labor saving.

Improved construction of driving boxes should also be looked upon with much favor.

It is within easy reach to design a box with an improved method of introducing the bearing brass, that will render double the mileage of that used in ordinary service at the present.

I have frequently heard conflicting opinions regarding proper size of crank-pins, able to bear with ease and safety the stresses exerted by cylinders of various capacities.

Proper dimensions of driving-axles, journals and truck-journals to bear certain loads have also been a source of contention, and, it seems to me, are necessary questions for this association to take up

for investigation, that it may be able to recommend proper dimensions and best material for these parts.

It seems altogether clear that a tonnage rating of engines is the only proper plan, and one that should be universally practiced.

I am fully aware that under some conditions of service the number of tons in a train is not easily attainable without involving some difficulty and delays, but I am far from believing that any serious objections can long exist in the way of obtaining the accurate tonnage of trains in transit.

Knowing the dimensions, it is easy enough to establish theoretically the maximum hauling power of a locomotive. The figures thus reached, however, are not always supported in practical service; hence the frequent disappointment in the actual power developed by locomotives.

It seems within easy reach of invention to devise a means of indicating in a simple way the actual stress or pull exerted on the engine draw-bar at all times.

This dynamometer-like arrangement could be applied to the draw-gear of the tender, and with the aid of a graduating indicator, placed where the extent of pull could be seen and noted, would be a most convenient and desirable locomotive attachment.

The maximum power of a locomotive being thus established in a practical way for certain districts and divisions, and a reasonably accurate train tonnage being known, would obviate much confusion and dispute, and add materially to the efficiency of the train service. These conditions would also serve to point out the men and the engines coming nearest to performing maximum duty.

Our country affords the greatest opportunity for educating the youth of any on the face of the globe. The American people, in their laudable anxiety, have spared neither pains, means, nor efforts towards educating the rising generation. There can hardly be any excuse, therefore, for any of our youth reaching the age of maturity without at least a moderately acquired common school education, yet how often we meet those who are absolutely illiterate.

It seems to me to be the plain duty of all intelligent bodies to aid in the spread of enlightenment and education of the people, and I am of the opinion that no better plan can be adopted by the members of this or sister associations than to refuse to employ any who are not possessed of a reasonably fair education.

It is a very noticeable fact that efficiency in the service is promoted in proportion to the education and intelligence of our employés.

The questions coming before you at this Convention are exceedingly important, and the reports of the committees are full and exhaustive, and I beg to ask your undivided attention to the report of each committee as it is presented.

Permit me also to repeat the hope that the great zeal you have heretofore shown in all subjects coming before you may be continued, and that deep and considerate thought in every instance may take the place of hasty conclusions. It is not the quantity of our work so much as its quality that bears the most fruit.

I respectfully ask the attention of the association to the necessity of having a standing advisory committee, whose duty it would be to advise with and consult members on any disturbing and unsettled question relating to the interests we represent, as well as to arbitrate matters of difference arising between persons selling, leasing or renting rolling stock, or in the construction of new machinery, and to otherwise perform the duties of an advising and arbitrating committee of the Master Mechanics' Association.

The Great Master Mechanic of the Universe in His deep wisdom has seen fit to remove from our midst twelve of our members in the past year. The secretary, in his report, will read the names of those who have departed never to return. I trust suitable action by the association will be taken to perpetuate their memory.

I would be ungenerous to the members of this association and untrue to my own feelings did I not publicly acknowledge my highest appreciation of my election as president one year ago, and I beg to assure you that the honor thus conferred, together with your words of deep sympathy, extended at a period of my saddest bereavement in the loss of beloved children, are tender memories of my heart, which will only fade from it when it ceases to pulsate.

In this Columbian year, when American inventive power, energy and enterprise have developed an exhibition, which for progressive ingenuity in the formation and display of the works of art is unparalleled in the history of the world, it is but proper that this association join in word, in sentiment and in deed this great educator of the human race.

Its edifying example should also inspire us to thoughts and labors of the highest order, and now as we face the sunrise of the second quarter of a century in the history of the association, our work should be tempered with such reasonings of wisdom that we may with credit to ourselves transmit it to others in such an advanced condition of growth as shall bear witness of our faithfulness and our devotion to the aims and interests of the association.

MEMBERS PRESENT AT LAKEWOOD CONVENTION.

Secretary SINCLAIR called the roll and the following members were present at this or subsequent sessions :

ALDCORN, THOS.,
ALLEN, G. S.,
AMES, L.,
ANDERSON, J. J.,
ANTZ, OSCAR,
ARP, W. C.,

BALL, A. J.,
BARNETT, J. DAVIS,
BEAN, JOHN,
BEAN, S. L.,
BERRY, J. H.,
BILLINGHAM, JOS.,
BISSET, JOHN,
BLACKALL, R. C.,
BLACKWELL, CHAS.,
BOND, I.,
BOON, J. M.,
BRADLEY, W. F.,
BREHM, W. H.,
BROOKE, GEORGE B.,
BROWN, DAVID,
BROWN, W. A.,
BRUCK, HENRY T.,
BRYAN, H. S.,
BRYANT, J. T.,
BUCKALEW, J. H.,
BURNS, C. H.,
BUSHNELL, R. W.,

CAMPBELL, JOHN,
CAMPBELL, JOHN D.,
CARMODY, T.,
CASEY, J. J.,
CHILDS, H. A.,
CLARK, DAVID,
CLARK, ISAAC W.,
CLEAVER, F. C.,
CLIFFORD, C. J.,
COOPER, CHAS. J.,
COOK, JOHN S.,
CORY, C. H.,

DAVIS, ED. E.,
DOLBEER, ALONZA,
DORSEY, J. B.,
DOWNING, T.,

ELLIS, JOHN J.,
ENNIS, W. C.,

FORSYTH, WM.,
FOSTER, W. A.,
FRENCH, R. E.,
FULLER, C. E.,
FULLER, WM.,

GARRISON, P. E.,
GENTRY, T. W.,
GILES, C. F.,
GILLIS, H. A.,
GORDON, H. D.,
GORDON, JAS. T.,
GOULD, AMOS,

GRASS, K. J..
GRIFFITH, FRED. B.,

HAINEN, J.,
HALLER, W. J.,
HARDING, B. R.,
HARRISON, W. H.
HATSWELL, T. J.,
HEDLEY, E. M.,
HENDERSON, G. R.,
HICKEY, JOHN,
HIGGINS, S.,
HILL, JAS. W.,
HINMAN, L. M.,
HOLMAN, W. L.,
HUDSON, E. E.,
HUFSMITH, F.,

JONES, W. F.,
JOUGHINS, G. R.,

LAVERY, W.,
LEE, C. W.,
LEEDS, PULASKI,
LEWIS, WM. H.,
LUTTRELL, J. W.,

MACBETH, JAS.,
MACKENZIE, JOHN,
MAGLENN, JAS.,
MANNING, J. H.,
McELVANEY, C. T.,
McGEE, F. H.,
McINTOSH, WM.,
McNAUGHTON, JAS.,
MEDWAY, JOHN,
MILLEN, THOS.,
MILLER, E. H.,
MILLS, STOTT,
MINSHULL, E.,
MINSHULL, P. H.,
MINTO, H. M.,
MITCHELL, A. E.,
MOORE, J. H.,
MURPHY, P. H.,

NAUFFER, JOHN G.,
NOBLE, L. C.,

O'HERIN, WM.,

PATTERSON, J. S.,
PLACE, T. W.,
POTTER, G. S.,
PURVES, T. B., JR.,

QUAYLE, ROBERT,

RANSON, T. W.,
RETTEW, C. E.,
REYNOLDS, W. W.,
ROBERTS, E. M.,
ROBINSON, JOHN,
ROSS, GEORGE B.,
RYAN, J. J.,

SAGUE, J. E.,
SETCHEL, J. H.,
SHEER, JAS. M.,
SINCLAIR, ANGUS,
SMALL, W. T.,
SMART, C. E.,
SMITH, F. B.,
SMITH, JOHN L.,
SMITH, WM.,
SMITH, W. T.,
SPRAGUE, H. N.,
STALDER, A. W.,
STEVENS, GEO. W.,
STEWART, ANDREW F.,
STEWART, O.,
STINARD, F. A.,
STOUT, HENRY K.,
SUMMERSKILL, T. A.,
SUTHERLAND, R. D.,
SWANSTON, WM.,
SYMONS, W. E.,

TABER, W. G.,
THOMAS, C. F..
THOMAS, H. T.,
THOMAS, J. J., JR.,

THOMAS, W. H.,
TONGUE, JOHN,
TURNER, CALVIN G.,
TURNER, CHAS. E.,
TYRRELL, THOS. H.,

VAIL, A.,
VAUCLAIN, SAMUEL M.,
VOSS, WM.,

WADE, R. D.,
WAITE, H. M.,
WALKER, C. W.,
WATTS, AMOS H.,
WEISGERBER, E. L.
WELLS, REUBEN,
WEST, G. W.,
WIGHTMAN, D. A.,
WILCOX, W. J.

Associate Members.

BAKER, GEORGE H.,
BARNES, D. L.,
CROSMAN, W. D.,
DEAN, F W.,
HILL, JOHN A.,
MARSHALL, W. H.,
POMEROY, L. R.,
ROBINSON, H. P.,
SMITH, JOHN Y.

Honorary Members.

DIVINE, J. F.,
THOMPSON, JOHN.

Minutes of Last Meeting.

The President—Gentlemen, the next business in order is the acting on the minutes of last meeting. As you are aware, the proceedings have been published, and it has been customary to pass that and to go on to the next order of business. It has been customary merely to accept the report as published.

A Membfr—I move that we accept the report as published.

The motion was carried.

The Secretary's Report.

Secretary Sinclair read his annual report as follows:

At last Convention your secretary reported that there were on the roll 475 active members, 16 associates and 20 honorary members, making a total of 511. At last Convention one active member was transferred to the list of honorary members. Since last year 8 active members, 1 associate and 3 honorary members have died, which takes 12 off the roll, and 53 new members have joined the association. The roll now stands—515 active members, 15 associates and 18 honorary members; a total of 548.

Death has taken from the association some of the oldest and most valuable members. In the list are: N. E. Chapman, one

of the charter members and a past president; L. C. Brastow, Matthew Ellis, H. L. Leach, Basil Manly, John Ortton, David Preston and S. W. Wakefield, all active members. The honorary members taken away are John Black, C. R. Peddle and Isaac Dripps. The latter was the first man in the world to hold the title of superintendent of motive power. The associate whom we have lost was Professor A. T. Woods, a young man who was gaining international reputation as a mechanical engineer.

The annual report was produced in the usual form, 2,000 copies having been printed. This report has been unusually expensive, owing to the large number of engravings and tables, which largely add to the cost of the work. There have been 1,547 copies of the report distributed to the members, to the subscribers to the Printing Fund, to technical and engineering societies and to the press. There has been an unusually active demand for this report by engineering societies abroad, and your secretary has supplied all the requests, most of the reports so sent having been complimentary.

The money collected during the year amounts to $2,747. Of this sum $865 has been received from contributors to the Printing Fund, $1,835 from dues and $47 from sale of reports. The consolidation of railroads is steadily reducing the receipts from railroads to the Printing Fund. Your secretary has lately been in communication with railroad managers on this subject, and there are good prospects that the leading companies will subscribe more liberally in future. Fifteen circulars have been sent out by your secretary during the past year, several of which contained information of value to all railroad men. The circular relating to the standards of the association issued by resolution passed at the last Convention, made an appeal for the more general adherence to standards. It was sent to all the general railroad officers and master mechanics on the North American continent.

The candidates for the benefits of the association's scholarships in the Stevens Institute of Technology were not so numerous as might have been expected, the difficult entrance examination having prevented several who were anxious to obtain a scientific education from entering. The indications are, however, that the candidates will soon exceed the vacancies. A son of Mr. S. A. Hodgman has held a scholarship for the second year with credit

to the association. Two scholars have attended the Stevens Preparatory School, one being a son of Mr. A. J. Cromwell, the other a son of Mr. J. D. McIlwain. These two young men will both enter the Institute in September. This will still leave one scholarship to be filled, and a student may enter either the Institute or the Preparatory School. The splendid engineering education which young men receive in the Stevens Institute of Technology ought to make members ambitious to see their sons enjoy the privilege offered by the association's scholarship.

ANGUS SINCLAIR,
Secretary.

SUBSCRIBERS TO PRINTING FUND.

Baldwin Locomotive Works	$25 00
Baltimore & Ohio	10 00
Boston & Albany	10 00
Brooks Locomotive Works	25 00
Burlington, Cedar Rapids & Northern	10 00
Central Vermont	10 00
Charleston & Savannah	10 00
Chesapeake & Ohio	10 00
Chicago & Alton	10 00
Chicago, Burlington & Northern	10 00
Chicago, Burlington & Quincy	10 00
Chicago & Eastern Illinois	10 00
Chicago & Northwestern	10 00
Chicago, Milwaukee & St. Paul	10 00
Chicago, Rock Island & Pacific	10 00
Chicago, St. Paul, Minneapolis & Omaha	10 00
Cincinnati, Hamilton & Dayton	10 00
Cincinnati, New Orleans & Texas Pacific	10 00
Cleveland, Akron & Columbus	10 00
Cleveland, Cincinnati, Chicago & St. Louis	10 00
Cleveland, Lorain & Wheeling	10 00
Colorado Midland	10 00
Copiapo Railroad	10 00
Concord & Montreal	10 00
Connecticut River	10 00
Delaware & Hudson Canal	10 00

Delaware, Lackawanna & Western	$10 00
Denver & Rio Grande	10 00
Duluth & Iron Range	10 00
Duluth, South Shore & Atlantic	10 00
East Tennessee, Virginia & Georgia	10 00
Fitchburg	10 00
Georgia Southern & Florida	10 00
Grand Rapids & Indiana	10 00
Grand Trunk	10 00
Great Northern	10 00
Iowa Central	10 00
Kansas City, Ft. Scott & Gulf	10 00
Lake Erie & Western	10 00
Lake Shore & Michigan Southern	15 00
Louisville, New Albany & Chicago	10 00
Louisville & Nashville	10 00
Maine Central	10 00
Minneapolis & St. Louis	10 00
Minneapolis, St. Paul & Sault Ste Marie	10 00
Missouri, Kansas & Texas	10 00
Mobile & Ohio	10 00
Newport News & Mississippi Valley	10 00
New York, Chicago & St. Louis	10 00
New York, Lake Erie & Western	20 00
New York, Ontario & Western	10 00
Norfolk & Western	10 00
Northern Pacific	15 00
Ohio & Mississippi	10 00
Pennsylvania	10 00
Pennsylvania & Northwestern	5 00
Philadelphia & Reading	10 00
Philadelphia, Wilmington & Baltimore	10 00
Pittsburg Locomotive Works	20 00
Porter Locomotive Works	10 00
Portland Locomotive Works	10 00
Raleigh & Gaston	10 00
Rhode Island Locomotive Works	10 00
Richmond & Danville	10 00
Richmond Locomotive Works	10 00

Rogers Locomotive Works	$50 00
St. Louis & San Francisco	10 00
Savannah, Florida & Western	10 00
Schenectady Locomotive Works	10 00
Southern Pacific	10 00
Terre Haute & Indianapolis	10 00
Toledo & Ohio Central	10 00
Union Pacific	10 00
Western Maryland	10 00
Western New York & Pennsylvania	10 00
Wilmington & Weldon	10 00
Wabash	10 00
	$865 00

Mr. O. STEWART, Treasurer, read the following report:

TREASURER'S REPORT.

In connection with this report a brief statement is necessary. Owing to shortness of funds in the early years of the association, a practice originated of paying the secretary's salary from the receipts of the year succeeding the period in which the work was done. This practice continued to the present year. When the report of last year was submitted it showed a certain large balance on hand, but the secretary's salary had not been paid, and a fictitious balance was always reported. The Executive Committee have determined to change this practice, and show the balance as it exists after all indebtedness is paid. The following report accordingly contains payment of the secretary's salary for two years. This appears to drain our resources closely, yet we have as great a real balance as we ever have had.

Dr.

June,	1892—To Balance on hand	$1,486 43	
"	1893—To money received from Secretary Sinclair	2,747 00	$4,233 43

Cr.

June,	1892—*The Saratogian*, printing	$8 00	
	Secretary's salary for 1891–2	1,200 00	
July,	" R. W. Ryan, stenographer's work	156 25	

August, 1892—	Bradley & Poates, engraving.	$208 00	
" "	DeLeeuw, Oppenheimer & Co., printing Annual Report	952 00	
October, "	Insurance on Reports	8 00	
June, 1893—	Electrotypes	5 55	
" "	DeLeeuw, Oppenheimer & Co., printing	172 25	
" "	Expressage, postage, telegrams, and other expenses.	149 82	
" "	Secretary's salary, 1892–3	1,200 00	
" "	Bradley & Poates, engraving.	19 28	
			$4,079 15
	Balance on hand		$154 28

O. STEWART, *Treasurer.*

DISCUSSION ON REPORTS OF SECRETARY AND TREASURER.

Mr. A. E. MITCHELL—I move that the reports of the secretary and treasurer be accepted and placed on file and printed in the proceedings.

Mr. J. H. SETCHEL—I believe that according to our rules they are to be referred to a committee that is to be elected.

The PRESIDENT—I do not find any rule that requires doing that, Mr. Setchel.

Mr. JOHN MACKENZIE—Mr. Setchel, perhaps, is correct. There is an Auditing Committee for taking care of those accounts, but for the receiving of the report I do not think it is necessary. The motion is simply that the report be accepted and received.

Mr. SETCHEL—That is the point I make. The motion was to receive them and place them on file. That is what I object to, precisely. I suggested that the rules require that the report be referred to the Auditing Committee, which is correct.

Secretary SINCLAIR—In the regular order of business the Auditing Committee will be appointed, and, of course, they take all the books and reports and go through them.

Mr. SETCHEL—Now, Mr. President, I move that the reports of the treasurer and secretary be received and referred to the Auditing Committee.

The PRESIDENT—The motion first made here was that the reports of the secretary ana treasurer be received.

Mr. SETCHEL—Received and placed on file, which, I make the point, is out of order.

The PRESIDENT—The Auditing Committee, Mr. Setchel, as is custom-

ary in past years, will take up the reports of the secretary and treasurer. That is part of their duty.

Mr. Setchel—Yes ; but they should not be placed on file, Mr. President. That is the point I make.

The President—We are all agreed as to the ultimate point to be reached, and if the first gentleman will withdraw his motion I will put your motion.

Mr. Mitchell—I will accept Mr. Setchel's amendment.

The motion was then put and carried.

Assessment of Dues.

The President—The next business in order is the assessment and announcement of annual dues. I will say that the Executive Committee have decided that the usual dues of $5 shall continue. It seems to be necessary.

Auditing Committee.

The President—We will proceed now to the election of an Auditing Committee. It is usual for members who are not officers of the association to nominate three members who shall be elected by ballot.

Mr. S. Higgins—I nominate J. H. Setchel for one.

Mr. Mitchell—I nominate Mr. Mackenzie.

Mr. Lewis—I nominate Mr. Mitchell.

Mr. Smith—I nominate Mr. Leeds.

After a protracted discussion on a motion that the secretary be instructed to cast the ballot for certain members, Messrs. A. E. Mitchell, P. Leeds and J. H. Setchel were elected members of this committee.

The President—The next business, gentlemen, is unfinished business. If there is no unfinished business we will proceed to the order of new business.

Delegates to Society of Railroad Superintendents.

Secretary Sinclair—I have a communication here from the secretary of the American Society of Railroad Superintendents. It says:

A cordial invitation is extended to your Convention to appoint a committee to attend the next meeting of our society, which is to be called in the fall by the Executive Committee, notice of which I will send you later. A similar invitation will be sent to the Master Car Builders' and Road Masters' Conventions, and I hope that these committees will meet our Executive Committee to see what action had best be taken towards bringing these organizations and ours into closer official relations one with another.

C. A. Hammond,
Secretary.

Mr. O. Stewart—I move that the communication be accepted and the committee appointed.

The motion was carried.

that the Committee be continued and that they be authorized by this association to confer and act with a committee of the American Society of Mechanical Engineers :

The motion was carred.

Secretary SINCLAIR—The next subject, Mr. President, is the report on Compound Locomotives. I have the printed copies of the report here. Most of the members have received them and there is also a supplementary report which has just been received and which we did not have time to put in the original report.

Mr. GEORGE GIBBS then read the following report of the Committee on Compound Locomotives.

COMPOUND LOCOMOTIVES.

At the Convention of 1890, a Committee appointed by your Association presented an able report on the general subject of compound locomotives. At that time it was impossible to obtain results from competitive trials of the compound and simple engine types, from the standpoint of American practice, for the reason that the former type was practically unknown here. Since then the business enterprise of one firm of locomotive builders, notably, has popularized the compound engine, so that a consideration of its features has emerged from the domain of a matter of scientific interest merely to one of great practical importance, and master mechanics everywhere will shortly be called upon to decide upon the desirability of the new type in ordering additional equipment.

Under these circumstances, your Committee felt disinclined to present a theoretical discussion of the subject, or an attempt at generalization from the incomplete data of trials of the type, which might be accessible from published reports. It was considered very desirable to present, rather, results of tests made under comparative conditions and with full personal knowledge of the facts; these tests to be carried out in a true scientific spirit and without any attempt to establish previously formed judgments.

To carry out this programme completely has, however, proved impossible; probably another twelve months will make it practicable; but to-day the engine is still in such an early stage of development, that designers are not fully prepared to furnish machines which they feel confident will fulfill all given conditions with justice to the new principle. Any results, therefore, which

your Committee have to offer, must be taken only as clearing the way somewhat for more conclusive trials in the future.

Your Committee wish to offer a word of caution here regarding locomotive tests in general. Those who expect to find that any set of tests, however complete, will give a complete history of the machine under all of the complicated conditions found in service, will be greatly disappointed. No scheme which would furnish such results has been advanced by authorities. The number of undeterminable variables entering into a road test is enormous, and the conclusion to be drawn from the determinable ones even is a most perplexing problem. Both these classes of variables are mutually dependent, and a change in any one introduced a change in the economic results of the engine performance. Probably a combination of two methods of test would furnish a conclusive basis for comparison, but unfortunately both these methods involve practical difficulties, making them almost prohibitory. The combination referred to is a shop test of the engine, where an absolutely uniform set of conditions could be maintained and its economy as a producer of a varying amount of work determined. These conditions of work could be made to imitate those obtained on road with all practicable train weights. To obtain the comparative economy of the locomotives as a *whole*, including the boiler and engine functions, a standard set of road tests is essential. This would involve hauling successively the same special train with each engine over the same road, at the same speed, with same crew, and with all extraneous conditions alike ; and afterwards repeating such tests for the entire range of train weights. It is needless to say that your Committee have not been able to entertain such a programme. In absence of this scheme, the best plan seemed to be an imitation of the *average service conditions* prevailing over a considerable period of time. It was assumed that if the test could be prolonged for a period of, say, one month with each engine, taking the trains as they were offered by traffic conditions, there would result an average figure for economy, which would be repeated month by month, and consequently give an idea of the economy appearing on the performance sheets.

Those present who have followed the literature of the subject are aware that designers are not fully agreed upon the best arrangement of the compounding features of a locomotive ; two,

three and four cylinder types have been all proposed and each has its advocates. These various types present three important considerations for discussion; first, their relative convenience and economy of first cost and repairs; second, fuel economy, starting power, etc.; third, the practicable cylinder volume ratios obtained for each and their influence on the second condition. Of course, the above is a general statement only and does not cover the entire question. The first consideration your Committee feel unable to discuss, from reasons which will appear later; it was decided to confine themselves to the second, as being the main question involved in the compounding principle, and the one which would furnish some useful results in competitive tests. The third condition is partially involved in the second, and is susceptible of proof in the same way; but to carry out this plan involved a test of two of the representative types of the compound, the two and four-cylinder, and in both freight and passenger service. For many reasons it was found impossible to arrange for so complete an examination of the subject, and the report presented below is confined (for the committee tests) to results from the four-cylinder type in freight service. All the needed facilities for the tests were offered by the C., M. & St. P. Ry. Co., without regard to the expense or inconvenience entailed, to whom your Committee wish to express their obligation, and also for the hearty co-operation of the officers of that road in working out the details with the Committee. It is proper also in this place to express their indebtedness to the Baldwin Locomotive Works, who offered to meet the wishes of the Committee to any extent in furnishing special types of engines for test, without charge, and gave other opportunities for a full examination of the subject, and also to the Thomson Meter Co., who furnished the two water meters used.

In the arrangements for tests it was decided to select for the running ground an example of a road through an undulating country, having moderately heavy grades to tax the hauling power of the engines, as well as level stretches where their speed capabilities could be tried.

For locomotives, two of the C., M. & St. P. Ry. standard Class "D" freight type were ordered of the Baldwin Company. These engines were to be identical in every respect, with the ex-

Secretary Sinclair—A motion would be in order that the discussion of this subject be the first order of business on Wednesday morning.

Mr. Forsyth—Then I make that as a motion.

The motion was carried.

Report on Standard Tests of Locomotives.

The Committee upon this subject herewith present their report after conference with a similar Committee appointed by the American Society of Mechanical Engineers.

It is of great importance to have a standard method of conducting locomotive tests, especially as the advent of compound locomotives is causing many tests to be made, and the data should be obtained and tabulated in such a way as to render results comparable. Locomotive testing is conducted under such conditions that the methods and precision of stationary engine and boiler tests cannot be used nor realized, but it is desirable to use such discrimination in conducting them that while precise results may not be looked for, such as are valuable for all practicable purposes shall be obtained.

The object of a test may be to ascertain the boiler performance, the valve and cylinder performance, or the general fuel performance per unit of train weight over a unit of distance. While the engineer or the motive power department will require the first two, the management is most interested in the last. In fact, to them the last is the only result of importance. In order to make the data collected complete, and to judge of the amount of power developed which is available to draw the train, a dynamometer car is necessary.

PREPARATION OF LOCOMOTIVES FOR TESTING.

The locomotive to be tested should be in good condition, either new, or thoroughly repaired.

The boiler should be washed out before beginning the trial, the fire side of the tubes cleaned, the exhaust nozzles cleaned and measured, the points of cut-off determined for each notch of the reverse quadrant, the port opening for each notch and the clearances obtained, and the steam gauge tested. In some parts of the country where water is very impure, it may even be necessary to remove the tubes for cleaning in order to have the boiler in proper condition. Even if this is not done, the condition of the tubes

should be ascertained and described. The pistons, slide valves and throttle valves should be tested for tightness, and the degree of leakage, if any, described. All leaks should be stopped if practicable.* The area of the full throttle opening should be ascertained and stated, and a scale should be used on the throttle lever so graduated as to show the proportion that the opening bears to the full opening. The coal and water spaces of the tender should be thoroughly cleaned. Other preparations will be mentioned when dealing with special apparatus.

Instructions should be given to the roundhouse foreman that no repairs nor alterations of any sort be made upon the locomotives without the approval of the person conducting the trial.

The men who operate the engine should not be changed during the trials, and the same methods of running and firing should be preserved.

The run selected must be one on which the same distance is covered each trip, and for comparative tests it is better to make three or more trips with each engine, under like conditions of speed and weight of train. The same cars should be used in each trip.

Through trains, unbroken from end to end of the run, must be selected, and it is desirable, in order to avoid many causes of inaccuracy, to test locomotives when hauling special test trains. It is worthy of note that many railroad companies have been sufficiently liberal to provide such trains.

The Committee desires in this connection to emphasize the importance of eliminating all unusual conditions when testing locomotives, for it is only by so doing that definite conclusions can be formed and satisfaction obtained. If the tests are carried out upon regular trains it is of the greatest importance to adhere to the time table, and in all cases to avoid making up time. In no other way can proper comparisons be drawn between results. If it is desired to test the engine when making faster time than the regular schedule, special trips should be made for this purpose.

The conductor of the trial must be familiar with correct methods of firing and running locomotives, and must insist upon good and uniform methods, and impress the importance of this upon the enginemen throughout the trials.

* See Appendix for directions for testing tightness of valves and pistons.

He must see that the coal supplied at coaling points is of the proper kind, and must weigh the coal personally, and keep accurate records.

TESTING WITHOUT A DYNAMOMETER CAR.

When the dynamometer car is not used, it is necessary to ascertain the power developed in the cylinders. This can be done by means of the steam-engine indicator. The best methods of applying this instrument, as well as methods of weighing coal and water, will now be described, beginning with

FUEL MEASUREMENTS.

The measurement of fuel in locomotive tests is not difficult so far as a determination of the total amount shovelled into the furnace is concerned. A weighed amount may be placed on the tender, and the amount remaining after a trip weighed and deducted from the original. In case water is used on the coal, a sample of the remaining coal can be dried and a correction made for water. By this method it is impossible to determine the amount used on any particular part of the route, but if the coal is placed in sacks containing 125 lbs. each, with a small amount weighed out on the foot-plate for beginning the trip, it is practicable to open the bags and empty the coal on the foot-plate as it is needed. In this way the rate of consumption can be approximately determined on any part of the trip. To determine the amount of coal used on the whole trip it is only necessary to count the number of bags that have been emptied.

When a locomotive which runs on short trips closely following each other is being tested it may be necessary to keep the terminal fire-level constant, and considerable care is required to do this. In any case, as testing a helping locomotive on a grade, in which one trip quickly follows another there will be occasion for the exercise of this judgment. If the test extends over a period of considerable length, any error in judgment will affect the coal quantity but slightly. It is, however, best to have the opinions of two observers.

The conductor of the trials should enter notes of repairs made on the locomotives tested, and any other events that occur, as

they will assist in explaining many anomalies. He should note as follows:

Dates of trials.
Class of locomotive.
Service in which trials were made, mentioning locality, etc.
Name of conductor of trials.

For each kind of coal he should note:

Kind of coal.
Location of mine.

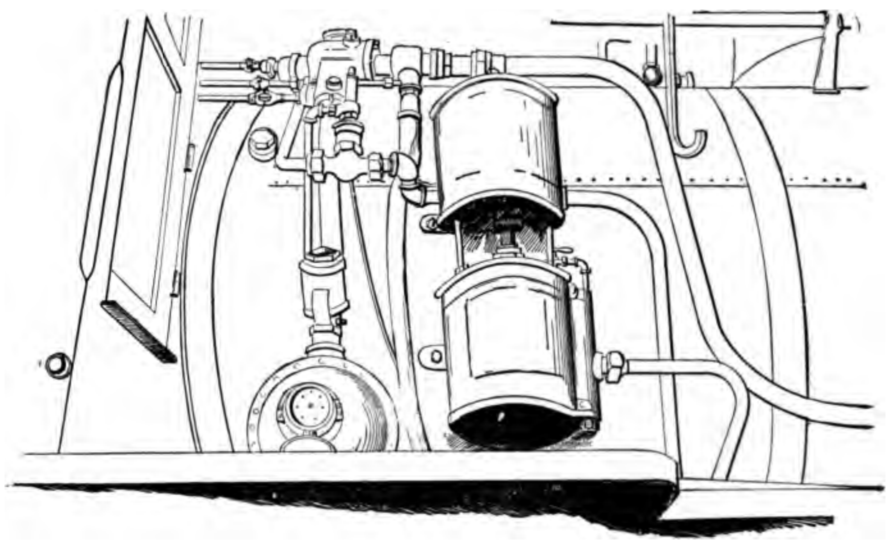

FIG. 1.

Name of mine and operator.
Appearance of coal.
Kind of fire made.
Notes of clinkers and ashes.
Notes of cinders in smokebox.*
Notes of sparks thrown from stack.*
Notes of cleaning ash-pan and smokebox.
The weight of coal consumed.
The weight of ash.
The weight of ash cinders in smokebox.*

* See discussion of this farther on, and its bearing on evaporative results, page 50.

The weight of water evaporated.

The number of cars in the train.

The weight of cars.

The weight of lading.

The number of passengers.

The state of the weather.

The direction of the wind.

The velocity of the wind, if an instrument can be devised for ascertaining this.

The temperature of the atmosphere.

The temperature of the feed-water.

The time on the road.

The time in motion.

The time the throttle-valve is open.

The steam pressure.

The time of passing important stations.

The coal should be analyzed, and its calorific value determined.*

It is important in making a full investigation of the combustion to take sample of the gases in the smokebox for analysis.

If the engineer who conducts the test is unable to analyze the gases a competent chemist should be employed, who will furnish the usual apparatus for extracting samples.

The gas analysis will assist in determining the best method of burning fuel, for thereby he can determine whether the correct quantity of air is admitted to the fire, whether the combustion is complete, and in general whether the fuel has been burned to give the best effect. In this connection, however, it should not be forgotten that, in a locomotive, that method of burning coal which produces the most steam will be regarded as the most efficient.

WATER MEASUREMENTS.

It has been found during the last year or two that meters are reliable and accurate within less than one per cent. for measuring the water used by a locomotive. The meters should be specially made for the purpose and, if possible, free from any material that is injured by contact with hot water. They should be placed so as to be read from the cab. (See Fig. 1.)

* See discussion of this farther on, and its bearing on evaporative results, page 50.

In mounting these meters, all pipes should be thoroughly cleaned before they are put into position, and a sufficiently large strainer should be placed between the meter and the tank. A most essential feature is to have a good check-valve between the injector and the meter; otherwise the hot water may flow backward and ruin the rubber-recording disks in the meter. Meters can now be obtained free from rubber, so that this difficulty is obviated. The check-valve should be used, nevertheless, in order to prevent heating and expansion of the meter and any resultant error. As a check upon the meter, however, other means of

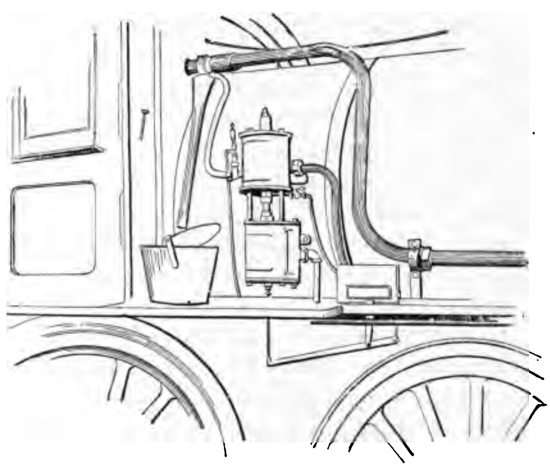

FIG. 2.

measuring the water should be employed. The most convenient method is to use a float attached to a wooden rod which slides upon a graduated rod, the lower end of which rests upon the bottom of the tank. This rod is graduated to show 1,000 pounds, and subdivided to 250 pounds.

The method of graduating the rod is as follows: Fill the tank, place the rod and float in the proper position for reading, and mark the stationary-rod zero at a level with the top of the float-rod. Draw from the tank 1,000 pounds, by drawing 333⅓ pounds into a barrel standing upon the scales, three times. Place the measuring device in position again and mark the rod, calling this mark 1. Again, draw out 1,000 pounds, mark the rod 2, and so

continue until the water is all drawn. If the tank has a uniform horizontal section, several thousand pounds can be drawn off at once, and the rod subdivided accordingly.

The float should be placed in a special opening, made as near the center of gravity of the mean horizontal section of the water space of the tank as possible, for at this point the water will remain at a constant depth with any change of level of the tank.

Another, but less convenient, way is to place a glass tube on each side of the tank opposite the center of gravity of the water space, and to graduate scales behind them by the same method as above described. The objections to this method are the inconvenience of reading the scales (especially at way stations where there is but little time), their liability to freezing in cold weather, and the possibility of injuring them at any time.

The float is always convenient and serviceable.

The waste from the injector should be ascertained by catching it in a vessel conveniently attached (see Fig. 2), or by starting the injector several times in the engine house and catching the overflow in a tub. The total weight of the water caught divided by the number of applications of the injector, gives the average waste. The observer in the cab should keep a record of the number of times the injector is applied during the trips, and thus obtain data for estimating the total waste. This method need only be used with a non-lifting injector. The injectors and check-valves should be in sufficiently good order to prevent any waste from the overflow except in starting.

When locomotive boilers are being fired hard the water rises above the normal level, and a measurement of water just after the injectors have been throwing comparatively cold water into the boiler is not an accurate one; the water shrinks and swells according as the firing is hard or as the locomotive is being worked. Hence, measurements taken under these variable conditions are necessarily approximations. There is also a continuous movement of the water in the water-glass, and a mean of the oscillations is not quite satisfactory. Although the amount of water fed into the boiler can be determined exactly by the use of meters, yet the inaccuracies of the location of the water-line in the boiler render water measurements on short runs almost impracticable. The six-hour test for a stationary engine is considered satisfactory

when successive tests will give the same results; but in locomotive work, unless the engine be kept quiet, as it would be when tested in a shed, a short test is of little or no value. It may be accepted that a determination of the water-line by the sound of the gauge-cocks is too uncertain to be admissible in locomotive tests, unless the run is a long one. In such cases the total amount of water used is so large that any errors in estimating the water level at the beginning or the end of the trip practically disappear, even in tests of not longer than an hour's duration.

A locomotive which is undergoing a test should have a water-glass on the boiler. Behind this should be a piece of wood graduated, and surrounding the glass and fastened to the wood should be a copper wire at the height at which the water should be left at the end of every trip. The tank measurement should not be taken at the end of the trip until the water in the boiler is at the standard height. The temperature of the water should be taken as it enters the tank at every station where water is taken, and tank readings should be taken before and after each filling.

Just before beginning a trip the water in the boiler should be at the standard height and the tank reading taken in order to ascertain the amount of water used while running, or per indicated horse-power per hour.

Extraordinary efforts should be made to prevent blowing off before train time and while running. The number of times and the length of time the safety-valve is blowing off should be recorded.

No water should be taken from the tank for any purpose except supplying the boiler, and the boiler should not be blown off during a test if it can be avoided. If it cannot be avoided, the water should be at the standard height before and after blowing.

Leakage of the Boiler. To test this, keep up as nearly as possible, without blowing off, the pressure to be carried, and note the fall of water in the water-glass in a given time while the engine is not running, say four hours. Of course, the injector must not be applied during this interval. The water meter can then be used to determine the amount lost by leakage by reading the dial, applying the injector until the water reaches the original level, and then taking a second reading. The difference will be the amount of water lost. All boilers lose more or less from this

cause, and if the test is to be a comparison between two different styles, the necessity for this information is obvious.

For the purposes of this coal trial the following form (*A*) should be filled out, after which conclusions as follows should be drawn:

Comparisons of evaporations per pound of coal, both under actual conditions and reduced to the equivalent conditions of "from and at 212°."

Comparisons of coal consumed per car mile and per 100 tons hauled one mile.

Value of coal *A*, 100%.

Value of coal *B*.

Relative value.

Percentage of superiority of one coal over any other.

[FORM A.]

LOCOMOTIVE PERFORMANCE—COAL TRIAL.

TRAINS, NOS. 0 AND 0.

R. R. LOCOMOTIVE CLASS ″ ″

BOILER PRESSURE, 000 LBS.

Distance, 000 *Miles*.

NO. ....

Fuel, ... *Coal.*

Between A. & B.

DATE.

Number of Round Trip.	DATE.	Weather.	Temp. of Atmosphere. Average.	Temp. of Feed-Water. Average.	Steam Pressure. Average.	Time on Road. H. M.	Running Time. H. M.	Av. Running Speed in Miles per Hour.	Number of Cars in Train.	Lbs. Coal Consumed per Trip.	Lbs. Water Evaporated per Trip.	Lbs. Water Evaporated per lb. Coal.	Coal per Car per Mile.	Total Weight of Train in Tons.	Tons Hauled One Mile.	Coal Consumed per 100 Tons per Mile.	REMARKS.
1																	
2																	
3																	
4																	
5																	
6																	
7																	
8																	
9																	
10																	
Totals																	
Averages																	

Recording Gauge." This gauge constitutes an exceedingly convenient piece of apparatus, and although subjected to unusually severe conditions on a locomotive, worked properly after the necessary regulation. The diagram furnished was, however, on too small a scale (one inch equal to one hour running) for anything except a general idea of steaming conditions ; it could undoubtedly be easily modified to give any desired scale. In taking indicator diagrams, the boiler pressure was observed in the usual manner by an attendant in the cab.

Measurement of Speed.—This factor was determined, as explained in the description of the dynamometer car, by two methods, the improved Boyer Speed Recorder, and the electric contact marks on the stress-diagram paper. Examples of the Boyer record will be found on Plates I and II. Scale of record was one-half inch to one mile run. For a locomotive test, it would be desirable to have the record enlarged to, say, two inches to the mile.

Measurement of Dryness of Steam.—For this purpose a calorimeter was used on four trips ; no record, was, however, taken on the remaining trips. The instrument was a copy of one devised by Mr. Barnes and described fully by him in the *Railroad Gazette* of November 27, 1891. It was attached at the rear of the steam dome and designed to show the priming at the point where the steam enters the throttle valve. Probably a better location would be in the steam pipes at the cylinder saddle, where the quality of the steam supplied at the main valves would be indicated.

Measurement of Injector Overflow.—For this figure, injector was put on for a number of times, say fifty, and the overflow caught and waste per time averaged. Improved Sellers injectors were used, and the overflow from these was found to be not only a quite constant quantity, but was much less than from the old Sellers pattern. Deductions from this loss were, of course, made from the water record of the meters.

Measurement of Waste at Pop-Valves.—Two three-inch pops were used on the dome. The waste from these when blowing off was found to be a surprisingly large quantity. Its amount was determined by causing the valves to pop for ten minutes and taking measure of the water used. In order to keep steam pressure up for this purpose, the engine was fired up and blown by an extra blower pipe led into front end from stationary boiler. The locomotive boiler was first filled to standard height on gauge glass, and after test refilled through the meter. The quantity blown off as above was found to be not less than three boiler gauges, giving an average of 168 pounds water or steam wasted per minute popping.

Measurement of Vacuum in Front End.—This figure was obtained for four trips by means of a glass U-tube gauge in the cab

automatically obtained, and therefore a more correct average of the power is secured. The object should be to take diagrams after equal numbers of revolutions. As this proposal has recently been adversely criticized, the reader is referred to remarks upon it by Prof. A. B. W. Kennedy in the discussion of Worthington's paper on Compound Locomotives, in the Proceedings of the Institution of Civil Engineers (London), Vol. XCVI, Session 1888-89, Part ii.

As it is difficult to carry out this plan when running fast, compromise may be adopted as follows:

Take indicator cards every two minutes, and read a speed recorder at intermediate minutes as well as when taking the card.

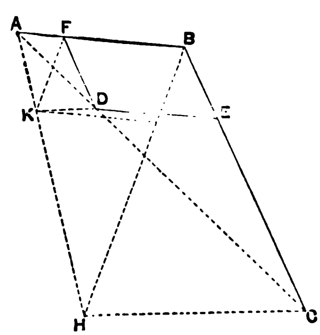

FIG. 4.

Then the mean of these two speeds may be assumed as the speed at which the card is taken, and on this the horse-power can be based with but little error.

In cold weather the operator should be thoroughly sheltered by a temporary box, but in warm weather this is hardly necessary.

Besides the indicator there should be located near the observer a revolution counter. This should preferably be an instrument that will, after starting, record revolutions for any desired number of seconds and then stop, starting each time from zero. Such an instrument is already in the market for taking continuous revolutions of dynamos and high-speed engines, and little or no difficulty would be experienced in obtaining one that would take the revolutions from some reciprocating part of the machinery. In the absence of such a device, a small high-speed ordinary

counter is serviceable. It should be so connected that it can be thrown into and out of gear by the operator at will, and thus the number of revolutions counted for any number of seconds as shown by a stop watch.

It would also be very desirable to have an electric connection between the indicator instrument and the recording apparatus of the dyamometer car when one is used, so that at the instant an indicator diagram is being taken, the fact is registered on the diagram paper in the car. The cards should be numbered consecutively and the record likewise.

Besides the persons taking the indicator diagrams, another

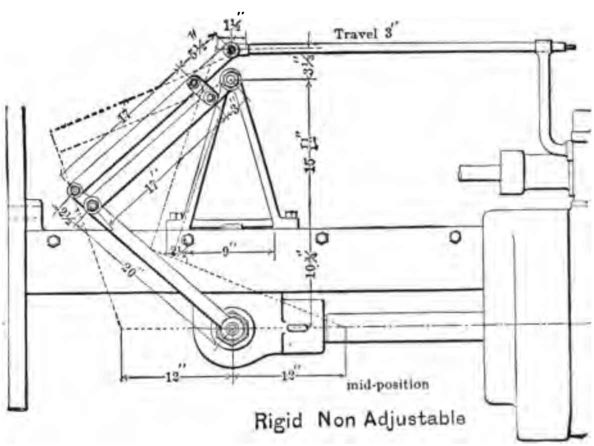

FIG. 5.

should be in the cab of the engine whose duty is to observe the point of cut-off by the position of the reverse lever, the position of the throttle-lever, the boiler pressure, the times of opening and closing the throttle—so that the time while developing power can be obtained—the times of leaving and arriving at stations, the time the safety valve is opened, and the number of applications of the injector. He should take the numbers of the indicator diagrams and the times when they were taken, and in general the car observations should be simultaneous with taking the diagrams. Either he or the person at the indicator should ring a bell in the dynamometer car when the indicator is being used.

During a trial, a special test steam gauge having a long siphon

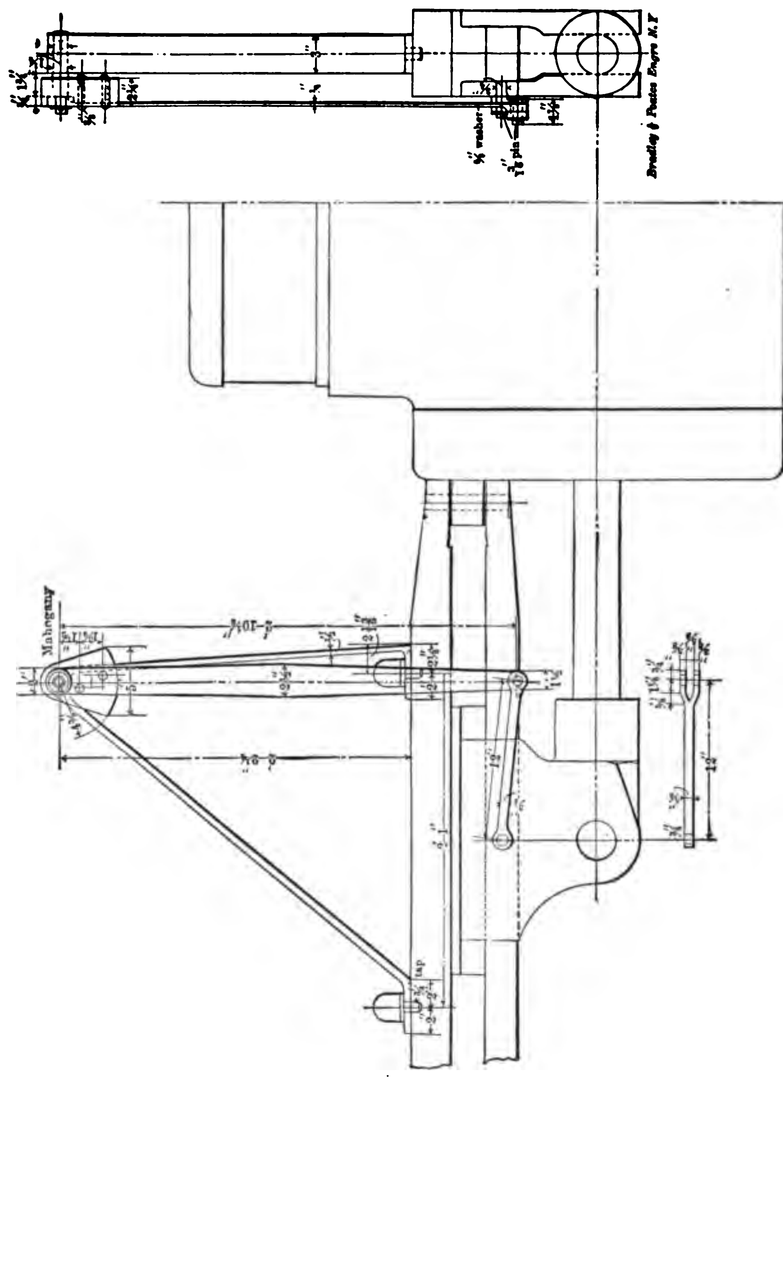

Fig. 6.

should be used, fastened to the left side of the front of the cab, so as not to be injured by the heat.

Placed so as to be read by the operator of the indicator, there should be a pyrometer for showing the temperature in the smoke-box, so located as to be swept by the main current of the gases

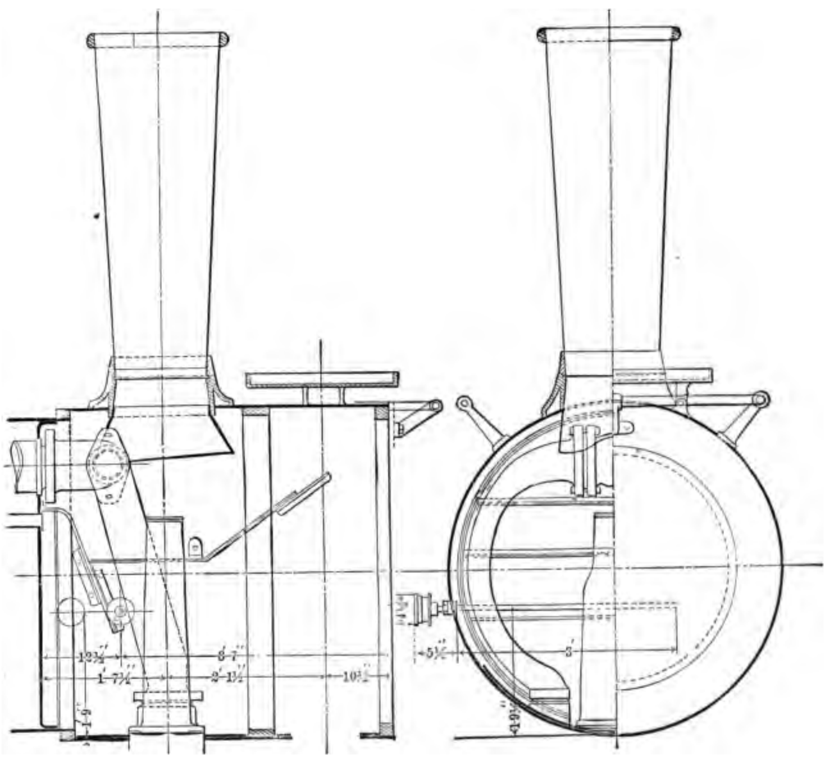

FIG. 7.

within. (See Figs. 7 and 8.) Near by there should also be a draft-gauge consisting of two glass tubes connected at the bottom, the top of one glass being connected with the interior of the smokebox and that of the other open to the atmosphere. This device is filled with water, and, when running, the difference of the levels in the two tubes in inches gives the force of the draft.

The pyrometer and draft-gauge should be read after taking each indicator diagram.

The Peabody throttling calorimeter can be used with success upon a locomotive, provided the percentage of moisture is not over five. Recent experiments show that locomotive boilers do not, except temporarily, contain even as much as one per cent. of moisture.

The following is a description of Peabody's throttling calorimeter, taken from his Thermodynamics of the Steam Engine, page 237:

Throttling Calorimeter.—A simple form of calorimeter, shown by Fig. 9, was devised by the author, which depends on the property that dry steam is superheated by throttling. Steam

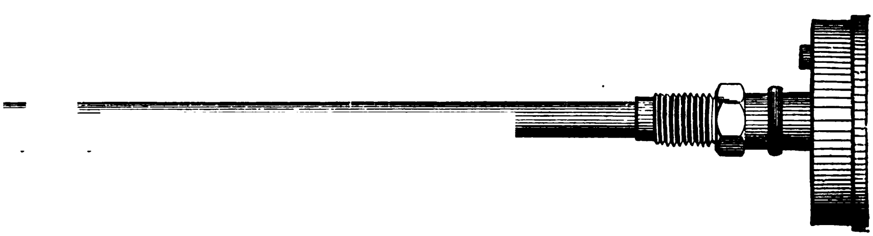

FIG. 8.

to be tested is brought in by a wrapped pipe *a*, below which the extension *c* with a drip at the end serves as a pocket to catch the water which may gather on the sides of the pipe. The valve at *b* is opened a slight amount to admit steam to the chamber *A*, and the exit-valve at *d* is used to regulate the pressure in the chamber. The temperature in the chamber is taken by a thermometer in a long cup at *e*, and the pressure is taken by the gauge *f*. Let the boiler-pressure be p, and let r and q be the latent heat and heat of the liquid corresponding. Let $p_{,}$ be the pressure in the calorimeter, and $l_{,}$ and $t_{,}$ the total heat and the temperature of saturated steam at that pressure, while t_s is the temperature of the superheated steam in the calorimeter. Then

$$xr+q=l_{,}+c_p(t_s-t_{,});$$

$$x=\frac{l_{,}+c_p(t_s-t_{,})-q}{r} \qquad (285)$$

Example—The following are the data of a test made with this calorimeter:

Pressure of the atmosphere.............. 14.8 pounds.
Steam pressure by gauge .. .. 69.8 "
Pressure in the calorimeter, gauge....... 12.0 "
Temperature in the calorimeter.........268.2° F.

$$x = \frac{1156.4 + 0.48(268.2 - 243.9) - 286.3}{892.7} = 0.988$$

Per cent. of priming, 1.2

A little consideration shows that this type of calorimeter can

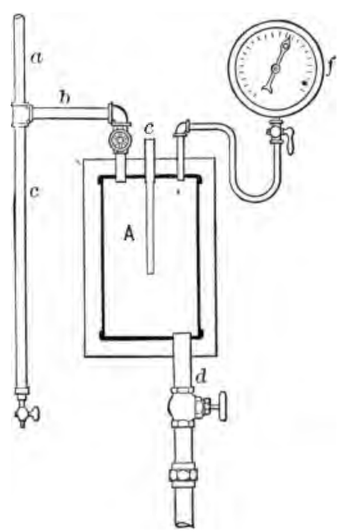

FIG. 9.

be used only when the priming is not excessive; otherwise the wire-drawing will fail to superheat the steam, and in such case nothing can be told about the condition of the steam either before or after wire-drawing. To find this limit for any pressure, t_s may be made equal to t_1, in equation (285); that is, we may assume that the steam is just dry and saturated at that limit in the calorimeter. Ordinarily, the lowest convenient pressure in the calorimeter is the pressure of the atmosphere, or 14.7 pounds to the square inch. The table following has been calculated for

several pressures in the manner indicated. It shows that the limit is higher for higher pressures, but that the calorimeter can be applied only where the priming is moderate :

LIMITS OF THE THROTTLING CALORIMETER.

PRESSURE.		
Absolute.	Gauge.	Priming.
300	285.3	0.077
250	235.3	0.070
200	185.3	0.061
175	160.3	0.058
150	135.3	0.052
125	110.3	0.046
100	85.3	0.040
75	60.3	0.032
50	35.3	0.023

In case the calorimeter is used near its limit, that is, when the superheating is a few degrees only, it is essential that the thermometer should be entirely reliable, otherwise it might happen that the thermometer would show superheating when the steam in the calorimeter was saturated or moist. In any other case a considerable error in the temperature will produce an inconsiderable effect on the result. Thus, at 100 pounds absolute with atmospheric pressure in the calorimeter, 10° F. of superheating indicates 0.035 priming, and 15° F. indicates 0.032 priming. So, also, a slight error in the gauge-reading has little effect. Suppose the reading to be apparently 100.5 pounds absolute instead of 100, then with 10° of superheating the priming appears to be 0.033 instead of 0.032.

It is often desirable to show temporary priming promptly. For this purpose the calorimeter has been devised which is shown in Fig. 10, and has given satisfaction.

This instrument consists of two pieces of brass pipe one inside of the other, leaving an air space between them. The outer pipe is screwed into the dome and extends close to the throttle in order to be in the most rapid current of the steam. At the inner end the two pipes are joined by a cap having a perforation $\frac{3}{32}$ of an inch in diameter. On the outer end of the inner pipe a globe valve is placed, and next and outside of it there is a tee with a stuffing-box for the insertion of a bare thermometer. Outside of

the tee there is another valve for graduating the flow of the steam. When shutting the outer valve, care should be taken to prevent the thermometer from being blown out of the tee. The whole device should be well wrapped with a good non-conductor of heat, and when so protected can be extended into the cab for convenience in using.

When the boiler foams, both valves being open, the thermom-

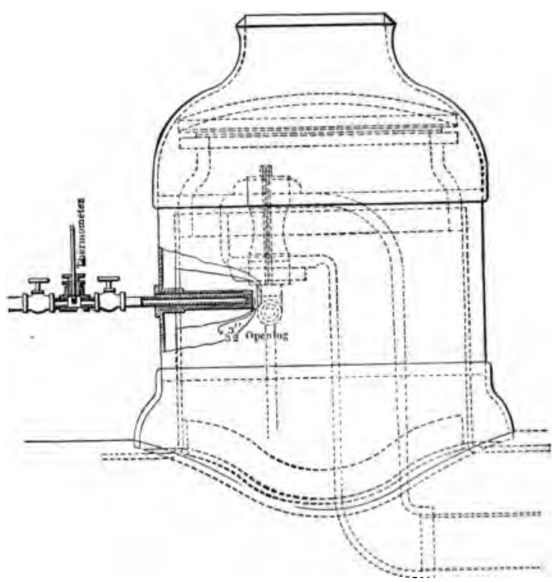

FIG. 10.

eter rapidly drops to 212°, and when the water passes out of the stack this temperature is invariably shown.

By allowing the steam to blow out of the pipe, the temperature of dry saturated steam will be shown and affords means of testing the steam-gauge.

The Peabody calorimeter can be used in the cab, and in order to make it sensitive enough to show temporary priming, the thermometer should be bare, as pointed out by Mr. D. L. Barnes, instead of being inserted in an oil well. The connecting pipe to the boiler should be well clothed, and before taking observations

the steam should be allowed to flow some little time in order to thoroughly heat the apparatus.

Concerning the location of the pipe for drawing the steam for examination, if the condition of the steam as furnished by the boiler is to be tested the position shown in Fig. 10 is correct. If the condition of the steam as it enters the cylinders is to be examined the calorimeter must be used at the front end of the engine and draw its steam from the steam-chest.

The Barrus calorimeter can be used on locomotive tests, and when large quantities of moisture are to be dealt with it is used with a separating apparatus.

Descriptions of the Barrus calorimeter can be found in the "Transactions of the American Society of Mechanical Engineers," Vol. X, page 327; Vol. XI, page 790; Vol. XII, page 825.

Accompanying a report of a test there should be a full table of dimensions and particulars of the locomotive as follows:

BOILER.

Kind of fuel.
Type of boiler.
System of staying crown-sheet.
Height of center above rail.
Diameter inside of smallest ring.
Length of firebox.
Width of firebox.
Length of combustion chamber.
Width of combustion chamber.
Length of grate.
Width of grate.
Outside diameter of tubes.
Length of tubes.
Number of tubes.
Thickness of shell plates.
Thickness of fire plates.
Width of water spaces.
Height of top of stack above rail.
Length of stack.
Smallest inside diameter of stack.
Working steam pressure.

HEATING SURFACE.

Heating surface of inside of tubes.
Heating surface of combustion chamber.
Heating surface of firebox.
Total heating surface.
Grate surface.
Ratio of grate to heating surface.
Total area through tubes.
Ratio area through tubes to grate surface.
Area of least opening in stack.
Ratio of same to grate surface.
Ratio of same to area through tubes.
Size of mesh of netting in smokebox.
Weight of water in boiler at 3 gauges.
Volume in cubic feet of steam space at 3 gauges.
Area of water space at 3 gauges.

CYLINDERS AND VALVE-GEAR.

Type of locomotive.
Diameter of high-pressure cylinder.
Diameter of low-pressure cylinder.
Stroke of high-pressure piston.
Stroke of low-pressure piston.
Diameter of piston-rods.
Cylinder ratio.
Travel of valves in full gear.
Outside lap of valves.
Inside lap or clearance of valves.
Lead in full gear.
Throw of eccentrics.
Notches in quadrant.
Release begins at, in general.
Compression begins at, in general.
Width of steam-ports.
Width of exhaust-port.
Width of bridges.
Number and size of exhaust-nozzles.
High-pressure clearance in per cent. of piston displacement.
Low-pressure clearance in per cent. of piston displacement.
Receiver volume in per cent. of high-pressure piston.

WHEELS AND AXLES, ETC.

Number of driving-wheels.
Diameter of driving-wheels.
Distance from center to center of driving-wheels.
Total driving-wheel base.
Diameter of driving-axles.
Length of driving-axles' journals.
Diameter of crosshead pins.
Length of crosshead pins.
Diameter of main crank-pins.
Length of main crank-pins.
Kind of truck.
Diameter of truck-wheels.
Truck-wheel base.
Diameter of truck-journals.
Length of truck-journals.
Total wheel-base of engine.
Distance of center of main driving-axle to center of cylinders.
Length of connecting-rods.

Tractive force per pound of mean effective pressure per square inch on pistons, reduced to high-pressure cylinder.

Computed by the formula $\frac{d^2s}{D}$ in which

d=diameter of cylinders in inches ;
s=stroke of pistons in inches ;
D=diameter of driving-wheels in inches.

In the case of a compound locomotive the pressure on both pistons may be reduced to an equivalent on one.

TENDER.

Water capacity.
Coal capacity.

WEIGHTS.

On drivers.
On truck.
Total weight of engine in working order.
Total weight of tender in working order.
Total weight of engine and tender in working order.

KINDS OF TESTS.

Reference has been made on the first page of this report to the objects and resulting kinds of tests. When a test is made, all kinds of data should be obtained in order to furnish results to all departments of a railroad company. These will be considered separately.

1st. If it is the custom of a railroad company to keep continuous fires in its locomotives, a test of two weeks' duration should be made under these conditions, weighing the coal and water every day. This is impracticable if the boiler requires frequent blowing off on account of bad water.

2d. If it is customary to drop the fire at the end of every single or round trip, a test of one week's duration under these conditions should be made.

3d. In order to ascertain the actual amount of coal and water used by the locomotive while doing its work, as nearly as possible, separate tests of one day's work should be made, whether on a single or round trip, burning the fire as low as possible on approaching the terminal station, and stopping combustion as completely as possible at intermediate intervals when not at work. The fire should be started as late as possible before train time in order to aid in the accomplishment of the objects of this kind of test. As before recommended, the water should be at the standard level just before the train starts on the trip, and the tank reading taken. The same should be done at the end of the trip. In this way the water used per hour per indicated horse-power can be determined.

By this method tests can be conducted by a uniform method throughout the country for purposes of comparison of locomotives with each other, and with stationary engines and boilers.

FINAL BASIS OF COMPARISON WHEN A DYNAMOMETER IS NOT USED.

As a practical and commercial unit for comparison the determination of amount of coal used per ton-mile is recommended.

As a unit for comparison of boilers the determination of the total heat received by the water in the boiler from a pound of coal is necessary when the same kind of coal is used.

When different coals are used the determination of the total heat derived from a pound of combustible is necessary.*

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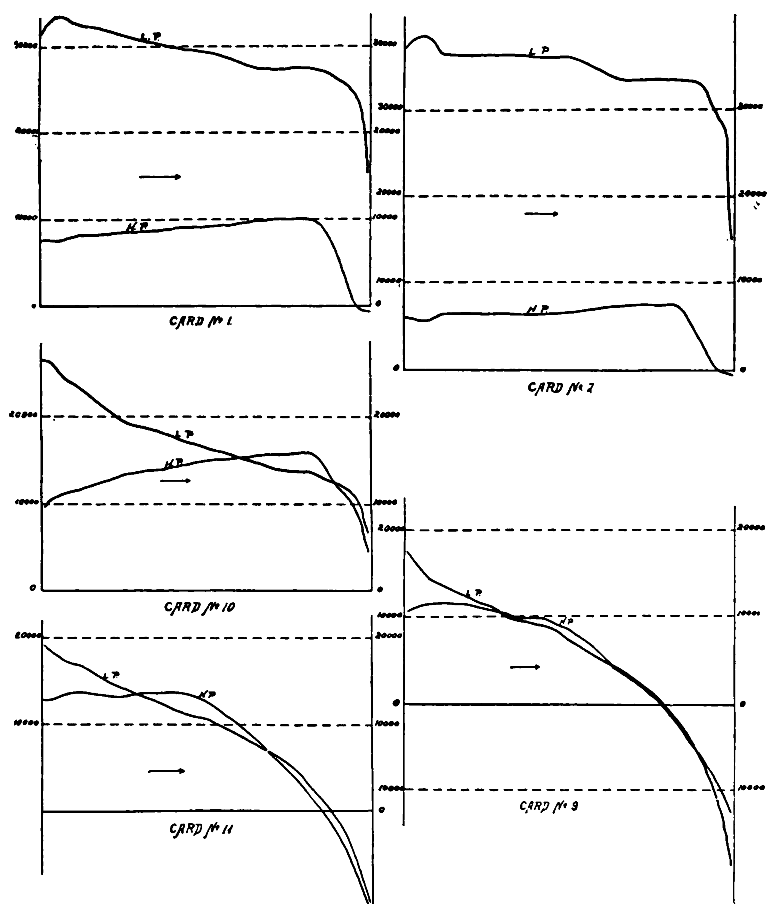
* See discussion of this, page 50.

pressure cylinder, as was of course to be expected. The data recorded on the original cards show the conditions to have been the same for the two cards, excepting a difference of one pound in the boiler pressure. The reason for the difference in pressure for the two cards is therefore not apparent.

Card No. 10 shows an excess of about 16,500 pounds on the low-pressure piston at the beginning of the stroke, which is gradually reduced until there is an excess of about 2,200 pounds on the high-pressure piston; the pressures are equalized again toward the end of the stroke. Cards 11 and 9 show a similar crossing of the pressure lines, the greatest difference being about 7,000 pounds in Card 9 at the beginning of the stroke. The indicator cards for this and the following diagrams were selected by your Committee as being good representative cards for different speeds and cut-offs, and may therefore be taken to represent the performance of the engine as fairly as can be done by a few cards.

Much has been written concerning the supposed greater uniformity of the rotative pressures in two-cylinder compound locomotives, as compared with simple locomotives. In order to determine how well this claim is substantiated in practice, the diagrams shown on Plate A were prepared under the direction of a member of the Committee. These diagrams show the combined rotative pressures on the crank-pins of a simple engine, a two-cylinder compound and a Baldwin compound for 100, 150 and 240 revolutions per minute. In preparing the data from which these curves were plotted, the total net effective pressure on the pistons was first taken from the indicator cards for every 10 degrees during one stroke, or one-half revolution. From these pressures were deducted the pressures necessary to accelerate the reciprocating parts, the formula used being the approximate formula given by Prof. Jacobus, in Volume XI of the Transactions of the American Society of Mechanical Engineers. The resulting pressures are those actually transmitted to the crank-pin. The tangential components of these resulting pressures were then calculated and plotted as ordinates on the diagrams shown, thus obtaining the actual rotative pressures for one side of the engine. These are shown by the unlettered curves on the diagrams. Finally the two sides, cranks at right angles, were added together, giving the lettered curves on the diagrams, the ordinates of which repre-

sent the total rotative pressures exerted at a radius equal to that of the crank. For the Baldwin compound cards 10, 11 and 9 were selected; for the simple engine cards 1, 4 and 12, and for the



Total Pressures on Pistons.
No. 827.

two-cylinder compound the cards shown on page 49 were selected from the blue prints of sample cards from Schenectady engines furnished by Mr. H. J. Small. The full-line curves *a a a* are

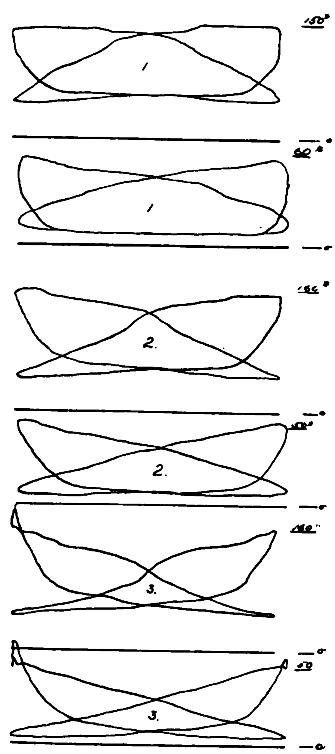
from the Baldwin compound; the broken-line curves *b b b* are for the simple engine, and the dash-dot curves *c c c* are for the Schenectady compound. The straight lines represent the *average* rotative effort in each case. It will be seen that for the steam distribution used for 100 revolutions, and with the weights of reciprocating parts as built, the simple engine gives a much more uniform pull than the others. Also, that if the compounds were reduced to the same average pressure, the variation would be nearly the same in both. At 150 revolutions, the four-cylinder compound gives the smoothest line and the simple engine is somewhat better than the two-cylinder compound. At 240 revolutions the four-cylinder compound shows the least variation and the simple engine the most. These facts are further illustrated by the following table, showing the proportional variation of each engine above and below the mean pressure. It is clear from this, that in this case, at least, the rotative effort or turning movement of the two-cylinder compound is not more uniform than that of other locomotives. There is also evidently a definite combination of steam pressure, cut-off, weight of reciprocating parts and speed for any locomotive with which it will develop its most uniform pull.

VARIATION IN ROTATIVE PRESSURES.

No. of Engine.	18½ Miles per hour. 100 Revolutions.		28 Miles per hour. 150 Revolutions.		44½ Miles per hour. 240 Revolutions.	
	Maximum above Mean.	Minimum below Mean.	Maximum above Mean.	Minimum below Mean.	Maximum above Mean.	Minimum below Mean.
827	15.1	18.2	10.1	10.2	21.0	25.0
822	5.0	6.0	15.9	22.2	33.3	43.3
1785	14.9	16.5	25.7	22.8	27.1	41.7

As showing in an interesting way the character of the oscillations due to the above (but somewhat modified by irregularities of the road), Plates III and IV have been prepared. These give each three 3½-mile sections of the dynamometer diagram paper, and were photographed direct; the record is, therefore, exactly

as drawn by the apparatus, with the exception of the letters and figures. The middle sections on each plate are taken at same location on road with each engine, and being at about the same speed, show clearly the characteristic oscillations from each. A study of these plates will give an idea of all characters of diagrams produced by the engines at all speeds. Engine 827 gives a steady



INDICATOR CARDS FROM ENG. 1785 C.P.

diagram up to 22 miles per hour; from 22 to about 48 miles per hour the vibrations are excessive, and at higher speeds again become more uniform.

Engine 822 gives at moderate speeds a much steadier diagram than the compound, having, however, at speeds between 25 and 30 miles per hour, an unsteady period, as with the latter. The

Reference has several times been made to the accumulation of cinders in the smokebox, and to evaporation per pound of combustible. If a locomotive exhaust has a severe action upon the fire, as is the case with most simple and some compound engines, a great many cinders are thrown from the stack. This is particularly the case if the trip is long enough to fill up the smokebox, after which all cinders are expelled. It is thus evident that in subtracting from the weight of coal used the weight of cinders and ashes, in order to obtain the weight of combustible, too little is subtracted, and too much combustible is obtained. The evaporation per pound of combustible is therefore fictitious and too small. The effect of this is not only to produce error, but to give a relatively worse showing for the engine that throws most sparks. If, therefore, evaporation is to be based upon combustible, it is best to estimate the amount of combustible from the calorimetric examination of the coal, for all residue left in the apparatus can be considered as non-combustible.

DYNAMOMETER RECORDS.

The dynamometer for measuring the resistance of the train, exclusive of the engine and tender resistance, should be able to record the following data :

A—The pull upon the draw-bar.

B—The speed at which the train is running.

C—The location of any point along the line used for reference stations.

A—The Pull upon the Draw-bar.

The force required to move the train, or the pull upon the draw bar, should be registered upon a strip of paper traveling at a definite rate per mile of distance traveled over by the train ; the scale upon which this diagram is drawn should be as large as is possible within any reasonable limits ; a scale of ¼ inch per 1,000 pounds pull is probably as suitable as any that can be devised, and the maximum registered pull need hardly exceed 28,000 or 30,000 pounds ; the height of the diagram should be measured from a base line drawn upon the paper by a stationary pen so located that when no force is exerted upon the draw-bar the base line should coincide with zero pull.

B—The Speed at which the Train is Running.

This record should, if possible, be obtained in two ways:

First. By an accurate timepiece, preferably a chronometer furnished with an electric circuit-breaking device. It is of considerable importance that the timepiece should have its circuit-breaking device very carefully made, to produce exact intervals of time marks, because, when the matters of acceleration or retardation of speeds enter into the data required, it is important that the time record should be correct. The question of length of intervals of time required is open for discussion. In most cases of ordinary work, five seconds intervals, or twelve to the minute, is probably as satisfactory as can be decided upon; for very careful work it would probably be advisable to have an auxiliary apparatus, something like the Boyer Speed Recorder.

Boyer Speed Recorder Diagram.—Its accuracy and reliability is without question when the device is properly mounted and cared for. It is not a delicate machine, and only needs ordinary attention. Its operation is well known to most of our members. It consists of an oil pump which works against a fixed resistance in the shape of an aperture through which the oil flows. The faster the pump runs the greater is the pressure in the oil cylinder. A piston in the oil cylinder, which moves against a spring, rises in proportion to the increase of pressure. As the piston rises, a metallic pencil marks the movement on a roll of prepared paper, which moves in proportion to the longitudinal movement of the engine. In the cab is a dial which indicates at all times the speed of the engine with only a small error. The diagrams record all stops and make an accurate record of the rate of acceleration.

Second. It would be very desirable to have, in addition to the apparatus just described, another one which produces a continuous curve upon the diagram paper, the ordinates of which, measured from a base line, would give the speed in feet per second, or any other convenient measurement; this could be obtained by modification of the Boyer Speed Indicator.

C—The Location of Any Point Along the Line Used for Reference Stations.

These location marks are most easily produced by having, at various convenient parts of the car, electric press buttons, and

"I have twelve engines built from the same specifications as engine No. 21; they were doing the same work during the month of April, and the general average was forty-four pounds of coal consumed per mile run. Engine No. 21 was picked out of forty-two engines doing the same service, she being the most economical simple engine.

"Thus: The Compound Engine No. 63 runs with 17 per cent. less fuel than engine No. 21, and 34 per cent. less than the general average."

Referring to the tables, it will be noted that the twelve-wheel Schenectady compound No. 367, when tested against simple engines Nos. 374 and 375, of the same make and general dimensions, gave a saving in coal of from 7.38 to 14.84 per cent. and a saving in water of from 6.24 to 13.68 per cent. per ton-mile. The greatest saving is shown by the tests between Sacramento and Truckee, in which a large proportion of the work was done, as shown by the profile, on a grade of about 116 ft. per mile. On the return trip, down grade, the saving was evidently very small, as shown by the figures for the round trips.

As Mr. Small points out, the Baldwin compound was at a considerable disadvantage, and it is but fair to add that on individual trips on which the two train loads were nearly the same for the two engines, the compound makes a much better showing.

The distribution of the work between the cylinders of the two-cylinder compound locomotives in these tests, is given on the sheets of sample indicator cards furnished by Mr. Small, as follows:

PERCENTAGE OF TOTAL WORK DONE IN HIGH-PRESSURE CYLINDER.

No. 361.				No. 1785.			
Cut-off.		Revolutions.	Per cent. of Work, H. P.	Cut-off.		Revolutions.	Per cent. of Work, H. P.
H. P.	L. P.			H. P.	L. P.		
23	23	60	40.3	20¼	20.5	30	45.0
21½	21½	96	40.4	19½	19.7	50	45.8
20½	20½	120	39.3	17½	18.3	60	46.5
20½	20½	108	39.2	15¼	16½	144	47.8
19½	19½	120	37.8	12½	14⅛	180	51.0
19	19	156	36.6	12½	14⅛	240	49.7
19	19	180	32.1	10¼	12⅜	240	48.5
17⅛	17⅛	192	31.	10¼	12⅜	300	52.7
17⅛	17⅛	240	29.5	10¼	12⅜	330	48.5

In a letter of later date Mr. Small sends prints and description of a device invented by Mr. F. W. Heintzelman, M. M., at Sacramento, for equalizing the work done between the high and low-pressure cylinders. The device consists essentially of an attachment to the ordinary valve-gear, arranged to give a differential cut-off in the cylinders.

The Old Colony tests are interesting for comparison with those on the Southern Pacific, and on account of the comparative excessive quantity of coal and water used by the simple engines per ton mile.

Mr. R. H. Soule, of the Norfolk & Western, and Mr. John Hickey, of the Northern Pacific, sent reports of tests of the Baldwin compounds on their respective roads, but as these reports have already been made public through the press, your Committee did not think any useful purpose would be subserved by their repetition here.

REMARKS ON THE RESULTS OF TESTS.

Your committee has felt considerably embarrassed in attempting to give a full analysis of data obtained, for the reason that it involved a more careful study of the figures than they have had an opportunity for. The tables were only completed in the final form at the time the report should have been in the hands of the printer, whereas a complete study of the results provided enough work for many days. It is hoped, however, that the explanation given of the tables is sufficiently full to enable others to study them at their leisure and provide information for future committee work. A hasty examination of the general averages will give the impression that they are so much at variance as to make definite conclusions impossible, and in this connection attention is again called to the few remarks regarding locomotive tests in general, which will be found at the beginning of this report. That, however, valuable data of a more comprehensive nature than generally obtainable is given by these tests, is considered certain by your committee. The condition which will be considered of first importance by railway managers is ability to handle a varying traffic with certainty and economy ; this involves a relative consideration of first, interest account on first cost ; second, the monthly repair bills ; third, the monthly fuel and small supplies bills. It is

therefore apparent that averages must be sought and that individual trips are only of importance in fixing the economical range of the engines, and thus enabling us to figure out the best proportion of parts.

Comparisons can be made on two bases, the coal and water consumed per ton hauled one mile, or on the amount of work done per unit of coal and water. The first will be found on Table No. 7, grouped under "Train Results;" the second under "Dynamometer Results." These last are considered the more exact for comparison, and of these preferably, the figures for coal and water per horse power hour, which not only give results based on total amount of work done, but include the speed factor or *rate of doing work*. As showing the reason for this conclusion, attention is called to Table No. 7, lines 24 and 37, from which is seen that the saving of coal per ton-mile by the compound on east-bound trips, is 3½ times that on west-bound trips, while the saving in coal per horse power per hour is in the ratio of about 1½; on the west-bound trips (see Table No. 3) the train consisted of twenty-nine loaded and two empty cars and weighed 583 tons, while east-bound, twenty-six loaded and seven empty cars weighed 754 tons. Differences of like nature will be found in other trips, and the number of loaded and empty cars is therefore no indication of the work actually done.

Two important divisions of the tables are those giving results with use of Braceville and with Pittsburgh coal. The former may be considered a fair example of good Western coal, used by roads in the territory west of Chicago. The main portion of test was therefore conducted with this coal. In order, however, to test the steaming qualities of the engines with the best sample of Pennsylvania coal, it was decided to make a few trips with Pittsburgh coal.

Much has been said about the characteristic exhaust obtained from the compound locomotive, in the two-cylinder compound especially, there is obtained one pulsation of exhaust to two in the simple engine. The character of this pulsation as observed by the sound of the exhaust and by the vacuum in front end, is very different from that of the simple engine, and tests with the two cylinder compound, previously made, had shown a certain percentage of steam economy obtained, and an *additional* percentage of

fuel economy, indicating that the softer exhaust was in some way responsible for more efficient combustion. In the four-cylinder compound, while the pulsations are of the same number as in the simple engine, it was thought the difference in volume of steam discharged from low-pressure cylinder and its lower average terminal pressure, might exert a similar action on the fire, so that while the compound might show fuel economy with the free burning clinkering Western coal, it might give very different results with the hard Pittsburgh coal. It is, further, well known that on account of the clinkering properties of the Western coal to successfully burn it and prevent clogging of the grate-bars, a sharper exhaust must be used than is needed for the non-clinkering Eastern coal. It, therefore, seemed reasonable to suppose that the softer exhaust in the compound would operate to disadvantage in burning the Western coal; hence the results shown in tables are somewhat unexpected.

Referring to column 38, Table No. 1, it will be seen that the size of the nozzles used for the two engines was different. The C., M. & St. P. Ry. standard nozzle is double, 3¾ inches diameter, and has been carefully designed to produce the best steaming with the kind of coal employed.

The compound originally fitted with this nozzle did not steam freely with Braceville coal until the nozzle was reduced to 3¼ inches. With Pittsburgh coal it could be enlarged to 3⅜ inches, but no more.

The effect of using Pittsburgh coal in the two engines is shown in the following table, which gives the percentage of economy so obtained in each engine as compared with its performance with Braceville:

Engine No.	Coal per H. P. hour.	Water per H. P. hour.
822 (simple)	28	9.2
827 (compound)	19	6

It is thus seen that in changing from Braceville to Pittsburgh coal, the improvement in economical performance was greater with the simple than with the compound engine.

In the opinion of your committee the explanation of the greater improvement of the simple engine is that with the friable Braceville coal its sharp exhaust as compared to that of the compound, caused a considerable proportion of the fine coal to be drawn

But for anything that is forged, his conclusion is that the inside is just as good as the outside. If that is true, of course it is just as well, so far as the strength is concerned, to finish the rod as not.

Mr. D. L. BARNES—I believe Mr. Kirkaldy's experiments were based on a shaft about twenty inches in diameter, forged with a big hammer. This whole question depends on the size of the hammer that does the work. If it is a light hammer. the skin of the material is very much condensed and made ductile. If it is a heavy hammer, it is treated very much the same throughout.

Mr. VAUCLAIN—In regard to the skin of a forging; if the skin of a forging were perfect, if there were no indentations in it whatever, it might be stronger. We have no evidence that the skin of a forging is any stronger than the interior of a forging, if the forging is made of the proper material. But my opinion is, from the experience I have had, that the skin of a forging is weaker than the interior of a forging, on account of its being full of slight indentations that even with the utmost care it is impossible to keep out. I might say, in connection with this matter, that it is desirable to have a proper amount of work put on the steel before the steel is used for forging. It happened in my experience to find out in purchasing steel blooms for specification which called for a piece of the bloom to carry a certain tensile strength and elongation, cut from the bloom and hammered under a hammer, that we could get a great many different qualities of steel that would fill the specification. We found that ingots cast 12, 14, 16 and 24 inches would all show practically the same results—pieces cut and hammered down to a square inch under a hammer and then tested. We found that to obtain a uniform quality of steel for forgings it was necessary to make our specifications read—a test piece cut from the billet must stand a certain tensile strength and a certain elongation. This necessitated the casting of larger ingots and the work being put on them in the steel mill before the billet was sold to us.

Mr. H. A. GILLIS—Several years ago, when on the Chicago & Alton, I saw—I think it was at Bloomington—that rods were being forged as Mr. Barnett describes. I do not know what the results were, but I thought if there was anyone here from the Chicago & Alton he might give us some very valuable information, as they practiced that method of forging.

Mr. FORSYTH—We have been forging rods at our Burlington shops quite a while, and we think they are very nice rods. We do not do it, however, because we think that the rod is better than one which is finished, but simply as a matter of economy, and only for use on freight and second-class engines.

Mr. BARNETT—As I understand Mr. Vauclain to say that the Baldwin's experiences were similar to my own experiences with wrought-iron scrap, I would like to ask Mr. Forsyth if his experience is with steel or with wrought-iron scrap?

Mr. FORSYTH—It is with each of them. We have made quite a lot out of steel.

Mr. L. R. POMEROY—Speaking relative to the Alton practice, during Mr. Wilson's time, he used to forge almost all of the rods, and he used two sets of dies, one for the rough and one for the finished forging, so that the result from the finishing die was a very smooth piece of forging. But when they compared the cost with putting either through a planer or milling machine; it cost materially more on that account.

Mr. G. R. HENDERSON—I understood Mr. Vauclain to say that they had to revise their specifications for steel billets so as to have the test piece cut right out of the billet instead of being drawn out. I would like to ask if that does not consume a great deal of material?

Mr. VAUCLAIN—Mr. Henderson is right. It consumes a great deal of material. But we know what we are doing. In the other way we consume very little material, but we know nothing about what we are doing after we get through. We simply had a parallel case with all blooms, no matter where we bought them. They all tested about the same as long as the piece was hammered down under a hammer to inch square. I might say that we had steel blooms which had high tensile strength, and the elongation was not much over 5 per cent. But now our steel blooms show the percentage of elongation that we desire in our forgings, and we are able to meet any specification by simply referring to the hot bar, and taking the billet that would meet that specification. We find that making the forging from such a billet gives us very little loss—not over 3.000 pounds.

Mr. POMEROY—I would like to ask Mr. Barnett if they finish the rod from one set of dies under the hammer? When I saw them making them at Montreal it was simply after that manner. That is where they differ from the Alton method.

Mr. BARNETT—I have finished from the one die, but believe that a showier piece of work could be turned out by the use of two dies. But I would be quite willing to submit with pride the kind of work turned out from the one set of dies to the observation of any master mechanic present in this room. In the matter of cost, the first two or three rods do run up expensive. It is difficult to find a forgeman who will at once forge a fluted rod. Practically, that man has to gain his experience on the first four or six pairs of rods at the expense of the railway companies, and most of you, I imagine, if you go through your experience, will not be particularly proud of the first few sets your green man turns out. But after a little practice on the part of that man the result is eminently satisfactory with one pair of dies.

Mr. PULASKI LEEDS—I believe it is an axiom among mechanics that what is right looks right, and I think that a forging that is worked up true and nice will undoubtedly stand more strain than one that is full of dents, etc. I think that in forging the ends they are swedged so that the fibers of the iron turn around the crown of the boss, and that they are apt to get a great deal stronger job than where they just take a flat piece and slab it on. At the same time I do not see why we are not getting a great deal of benefit from the forged rod, as far as the working material is concerned, in the

sents the weight of the train and engine in tons. The vertical line represents the train-work done as obtained from the dynamometer and it is plotted in terms of foot-tons of work done per pound of water evaporated. That does not take into account the work done in the engine. That figure we did not know how to ascertain. The blue line is the compound and those little dots represents the location of each one of the trips made. Take that trip just up at the top there which is singled out for comparison. You will see by running your eye up the line of 550 tons, that is taken with a train of about 570 tons weight. That gives the vertical position. The horizontal position is taken by looking at the table. So that is about 47 tons of work per pound of water evaporated. The others are obtained in the same manner. So those points represent on that table the water economy or cylinder performance of the two engines, and their position in relation to each other for the same weight of train gives the economy of the engine. You will note that through those colored points we have drawn two dotted lines. That is an attempt to represent an economy curve for the two engines at the different loadings. That is made in dotted lines, only because the points did not fall in a smooth curve and we were not certain of the location. We need more points to determine that. But there are enough points to fix that position as being nearly correct. In fixing it further, we have considered each of those points in turn and looked over the tables to determine whether that particular trip represented average conditions all through. For instance, the trip is No. 18. That trip is much more economical than any other obtained with the compound engine, and obviously does not represent an average result. The reason for that extraordinary economy is shown by reference to the tables. That train, if I remember rightly, was a through, light train with no stops. I think it was made on Sunday with a clear track, and the conditions were very favorable, so that the engine was working at the most economical speed and cut-off. There was no switching done. It was, therefore, a very economical train-load.

On the simple engine, down on the middle of the table, there is an oscillating trip there. That we also threw out for the reason that it was a way-freight that did a large portion of the work in switching. If then those curves represent fairly the position of the average trip at any one point of loading, it will be seen that the compound engine is not only more economical than the simple one but that it holds its economy better.

We take two other curves headed "Coal." I will say here that we cannot expect those results to be as nearly correct as the others, because the errors in the cylinder and in the furnace are added to those. Here you have the weight of the train and engine in tons, and here is the dynamometer train-work foot-tons per pound of coal. These curves have been carefully thought over and put in there. If they are anywhere near right, the compound engine is more economical, simply because the economy rises more rapidly. The point of maximum is reached in the two engines at the same point, and it falls off a trifle less rapidly in the compound than in the simple engine. One cause of the discrepancy in those compounds is this: In the

ɔrt it is stated that the weight of the train is no exact indication of the ›unt of work done. Here we have taken that as a basis. But there are nany variables coming in there that it is almost impossible to expect a e coincidence.

Mr. J. N. Barr—Will those lines represent the economy of the perform-e of the engine at the same steam pressure?

Mr. Gibbs—They do not. They represent the two steam pressures ed in there irrespectively. That curve for water represents the Pitts-gh coal performance. In this we could not put in Pittsburgh coal. ›se points look quite far apart, but if you will remember that at the base his diagram is the zero line, the percentage of variation is not so great ıt first glance would appear.

Mr. Barr—This is a very important subject, and the committee has dis-ered a great many things that are not settled yet. In view of the large ›unt of valuable work which they have done, and the importance of these s that are unsettled and the manner in which they have been impressed :he minds of the committee, I make the motion that this committee be tinued for another year.

The motion was seconded and carried.

Mr. A. Dolbeer—There are several representatives here of locomotive .ders—from Brooks, the Baldwin, the Schenectady, the Rhode Island :omotive Works, and others—and I would suggest that for our information y be requested to give their views in the matter. (Applause.)

The President—Mr. Vauclain, will you please enlighten us upon this ject?

Mr. S. M. Vauclain—I have been called upon to open up the discussion compound locomotives on the part of the locomotive builders. You will remember that when I was at the last convention we had quite a long .t upon them, and at that time I tried to inform you of the state of the so far as the Baldwin Locomotive Works were concerned. At that time ›ld you we had taken orders for upward of forty compound locomotives. : had seventeen built and delivered of the type which your committee re examined on the Chicago, Milwaukee & St. Paul Railroad. I then l you that if the demand for compound locomotives kept up at the same e, that before the end of the year we should have taken orders for one ndred compound locomotives. I am happy to say to you that before the l of the year came we had taken orders for one hundred and sixty com-und locomotives, and at the present time we have over two hundred com-und locomotives in service, and we have a number under construction at works. This, I believe, is four or five times the number of compound omotives that have been built by all others in the United States up to : present time.

The test that has been made on the Chicago, Milwaukee & St. Paul ilroad has been a very extensive one. In fact it has been a crucial test compound locomotives, and it should settle forever that there is an econ-y in compound locomotives. The percentage of economy that is given

cheaper to finish the rods from the milling machine. In fact, it seems to me, it is in the neighborhood of 35 per cent. cheaper, as he expressed it, and he had figures to support what he said. That is, having a miller that would cut clean from end to end.

Mr. WILLIAM SMITH--The trouble in a great many shops is that they have not got the milling machines to mill them out with. We have no milling machine that would mill them out in the proper time. I could make them cheaper under the die than I could under the milling machine we have in our shop. Of course, Mr. Vauclain probably has milling machines that could finish in a quarter of the time that we could. We have to work to suit ourselves to circumstances.

Mr. VAUCLAIN—In regard to the cost of manufacturing fluted rods under the hammer and on the milling machine, fluted rods can be made for about 25 per cent. at our works of what it would cost to make them under the hammer. In addition to that there is another element that enters, and that is, whether we employ skilled labor or unskilled labor. If we have an experienced hammer man, should he stay out, as that class of men sometimes do, we would have to wait until he came back to get some more fluted rods. But if we do the work on the milling machine we not only get it done better, but if the milling man goes out we put on another man to run the milling machine. We believe that the day of the blacksmith shop has passed, that the mechanic is going to be the blacksmith. About seven years ago we had some four acres of blacksmith shop and we built ten locomotives a week, of very light weight compared with the locomotives that we build to-day; while at the present time we have two acres of blacksmith shop and we build twenty locomotives a week.

Mr. SMITH—I think most of the railroad people here will say that we cannot control our employés as the Baldwin works and other Eastern manufacturing concerns can control theirs. They have mechanics developed through three or four generations. We cannot get a man that will run two machines. They can get a man that will run three or four machines, and, of course, their work is done much cheaper than ours.

Mr. F. W. DEAN—There is one point here that has not been touched on, and that is, improvement in milling machines. I had my attention called recently to a machine made by the Pratt & Whitney Company that rather revolutionizes practice in that respect. The old way has been to run the milling machine so that the cutting edge moves in the opposite direction to the movement of the rod. But they now make the machine so that the cutting edge moves in the same direction, so that the action of the milling machine is to pull the rod under, and the success of that method, they inform me, depends on the weight of the milling machine. The ordinary idea is that the tool would tend to pull the rod under the machine and tear it all to pieces. That seems to be a question of the amount of metal in the machine, and they inform me that the work could be very much more readily done with the new method than with the old.

The PRESIDENT—If you do not desire to say anything more on this subject, a motion to close the discussion will be in order.

Secretary SINCLAIR—I move that the discussion be closed.

The motion was carried.

DISCUSSION ON BROKEN CYLINDERS.

Secretary SINCLAIR—Mr. Gentry has presented this question:

"Has any Member Using Heavy Consolidation Engines Had Trouble with Broken Cylinders and Frames; also Cylinders Getting Loose, etc.?"

Mr. GENTRY—Mr. President, I referred particularly to consolidation engines with fireboxes on top of the frames, necessitating very long saddles. We have had and are still having considerable trouble from our cylinders breaking off at the saddle, right next to the frame. We have had them leave our engine house without a crack that we could discover, and before running sixty miles we had the cylinder break bodily right off, while the engine was in very fair shape in every other way. There was no unusual thump in the rods. It was in very fair order. We found it also very hard to keep the cylinders tight. I brought the subject up, thinking that probably other members had had the same trouble, and I might learn something from their experience.

Mr. DAVID BROWN—Do I understand the gentleman to speak of cylinders breaking on the saddle from the frame up?

Mr. GENTRY—Yes; right square through the saddle.

Mr. BROWN—We have had 19 x 24-inch passenger cylinders breaking in that way and we have put a brace back and front of the cylinders and run them quite a long time. But we attribute it more to the thinness of the walls. When we put new cylinders on we made the walls thicker, and we did not seem to have any further trouble. With engines that have the boilers on top of the frames, there is a tendency to swing probably a little more, and they have given us trouble, but by bracing them with a cross-brace back and front, tying them together as it were, we seem to have overcome the trouble.

Mr. MITCHELL—We have a large number of that type of engines, and we had the same trouble with them, but we overcame it to a great extent by increasing the walls of the cylinders, and at the same time putting a T-brace between the upper and lower member of each frame, just back of the cylinders, so as to protect those bolts from working through the cylinders, and putting braces laterally across the frame. In some instances, we have put a yoke right around the upper and lower member of each frame, both fore and aft of the cylinder.

Mr. JAMES MCNAUGHTON—I might say that we have had a few cylinders break as described by Mr. Gentry, and we have overcome the difficulty, as the other gentleman describes, by bracing the cylinders back and forward, and in some cases taking the flange off the saddle both forward and back, and tying both the cylinders together with a planed plate. But the fault is

Mr. A. J. PITKIN—I simply wish to call attention to the report sent to Mr. Gibbs by Mr. Small giving the equalization of work in the two-cylinder compounds believing as we do thoroughly in the two-cylinder compound engine as being a case of the survival of the fittest. By reference to the table on the thirty-fifth page you will find the distribution of the power in the two cylinders is quite variant. Since building this engine, which is one of the earliest, we have overcome that difficulty, and in later cards we have an equalization of power which is very nearly perfect. We have a description of the two-cylinder type which I would be glad to furnish to any one who would like it. Cutting off at the various points, we have at full stroke a variation of power of only 2.5 per cent in the two cylinders; at 17-inch cut-off, a variation of only 2.17; at 13, 2.54; in no case a variation of three per cent. So that this, we think, will silence all the criticism about our engines wobbling by excessive pressure on one side.

We went into the compound engine business, first, simply as an experiment, because we believed from the results we saw obtained abroad that there was undoubtedly great economy to be obtained therefrom. We have sold three compound engines under solicitation, two of those going to the Michigan Central and one to the Pennsylvania for their limited train between Philadelphia and Pittsburgh. Out of fifty-five or sixty compounds which we have built, these are the only three that we have sought to build, and the others have come to us directly from the roads. In a number of instances where the question has been raised whether we would recommend the compound, we have said decidedly, "No. Here are the results. You can take the compound, or the simple engine, as you please." Possibly we may be a little selfish, because we have built all the simple engines we could possibly build during the last year and could not turn out as many compounds, perhaps. But we are getting special tools in and will be ready to build the engine that is to come.

Regarding the different types of compounds, it is simply a case, as I said, of the survival of the fittest. Simplicity is the main point to be sought for. We think that the two-cylinder type is the simplest type that can possibly be obtained, and we get a sufficient rate of expansion to give good economical results, the economy varying from 15 to 30 per cent., according to the varying conditions of service; this in comparison with simple engines of identically the same design. I would be pleased to answer any questions that may be asked.

Mr. JOSEPH LYTHGOE—We have built quite a number of compound locomotives. We are not advocating them strongly. If people want them, we build them. We think we have a good type. We build a two-cylinder type. We are making a good showing on all the engines that we have running. They are doing very satisfactory work, making a saving of anywhere from 15 to 37 per cent. I do not think there are any of them that are running with less than 15 per cent. in saving. We have just received a report from the Brooklyn Elevated Railroad which is not in this report of Mr. Gibbs, where they have three of our engines and

are running those engines in competition with twelve others of exactly the same type. The engines I speak of were changed over from the simple to the compound. They have been running them against twelve other engines for some months. They have run 15,000 miles on that road, which means several months' service. In that report which comes from the railroad company, and with which we had nothing whatever to do—we had no one there to see it made — they claim a saving of 27 per cent. against the twelve engines for the time run. They do not give the time that it took them to run the 15,000 miles, but it must have taken them some months. As I said before, we are ready to build compound locomotives. We have one passenger engine running on the New York, Providence & Boston. I believe Mr. Butler, of that road, is here, and I have no doubt that he can tell you something about the performance of that engine. We have also built some four-cylinder engines of the Johnstone type, and we are building ten more of that pattern now, some of them for the Mexican Central Railroad and some for other roads. Mr. Johnstone reports that the engines are working in a very satisfactory manner and showing very good economy. I believe Mr. Barnes has been conducting some tests of those engines, and I would like to hear from him as to how they are getting along.

Mr. D. L. Barnes—I have a telegram that my engineer of tests from Mexico has arrived in Chicago. He finds considerable saving with those engines—15 to 30 per cent., as near as he can estimate, the record not having been worked up. The Mexican Central is a road that is well adapted for the compound locomotives. Coal ranges in price from $18 to $22 per ton. The saving per year for a compound engine, on the basis of the results obtained from our experiments, is about $15,000 per engine. On some sections of the road they use wood. The wood has to be carried over the mountains on the backs of mules, and it costs considerable by the time it reaches the road.

The President—Mr. Tandy, can you enlighten us any on the compound locomotive?

Mr. H. Tandy—The Brooks people have been so busy building simple engines that, as a matter of fact, they have not given that time and attention to compound engines which they otherwise would have done. But for our own satisfaction we did build a compound engine of the two-cylinder type and placed it upon a road with the understanding that if they desired they could purchase it at the expiration of six months, and, as they did so, I presume that is evidence that the engine gave satisfaction. This engine has been running in freight service since last September, and has quite recently been put in pretty severe passenger service on trains that will average from ten to fourteen coaches. The engine, so I am told by the railroad officials, has been effecting a saving of from 27 to 32 and 33 per cent. We are also building a compound engine of the four-cylinder type, for our own satisfaction simply, and we are vain enough to think that we shall get quite as good results from that as we did from the other one. I think that the

question of compounding is so well understood by all master mechanics that it is not necessary for me to advocate either one type or the other. This question has been thoroughly discussed and earnestly looked into by all these gentlemen, and I expect that they will now be inquiring for compound engines, and the Brooks people are ready to build compound engines of any type when called upon to do so.

The PRESIDENT—If Mr. Dean is present we would like to hear from him.

Mr. F. W. DEAN—I think, possibly, it would be rather more in order for Mr. Lauder to talk about the compound locomotives that I have been associated with. I think Mr. Lauder had better begin it, and then if there is anything to add I will try to add it.

I would say with reference to that engine, that it is substantially the Old Colony type of engine. That is to say, those alterations have been made which were necessary to make it a compound engine. It is of the two-cylinder type, and it has a cylinder ratio of 1.97 to 1; that is rather unusual; that is to say, the high-pressure cylinder is unusually large. Before the engine was tried I had some misgivings in regard to the proportion being a good one. The cylinders are 20 and 28, and I regretted somewhat that they were not 19 and 28. But after trying the engine, I think the sizes were wisely chosen, and if I were to design another engine I certainly would adopt just about that ratio.

Mr. F. D. CASANAVE—We have had no experience with compound locomotives on our road so far, having had only four or five, which are scattered over a large territory, and we have very few figures to show the economy. From somewhat imperfect trials which we have made of one compound of one type we have found an economy of about 5 per cent. in fuel. There is no doubt, from all the figures shown, that there is economy in compounding and that the economy will be greater where the price of coal is larger, but it seems to me that one of the essentials is to confine the compound locomotive to the simplest form. That matter of repairs is one that must be looked to in order to ascertain whether any saving in fuel will not be absorbed by it. The compounding of locomotives is certainly in its infancy. If I were to take the money out of my pocket to equip a railroad I hardly think I would go very extensively into compounding. I would wait for a year or two until it is clearly shown where the range of economy lies. (Applause.)

Mr. L. B. PAXSON—We have upon the Reading Railroad some twenty-seven compound engines. They are of three types; one type is for working on our mountain grades, pushing coal up, that were built to be the equivalents of consolidation engines of 22x24. We have ten engines for fast freight service that were built to be the equivalents of 20x24, and we have five passenger engines that were compounded to be the equivalents of our 21x22 engines. Now we have not, for certain reasons, attempted to make any scientific tests of these engines. We put them to work alongside of simple engines doing similar work and all that we have been watching is the quantity of coal used per month as returned on our books. Our engines

on the mountains show a saving of coal reported between 25 and 30 per cent. The fast freight engines show from 12 to 17 per cent.; and as to the passenger test we only had the one which has been making two months run, and it is hardly fair to say what her percentage is, although it is between 9 and 10 per cent. The engines have been running along very nicely. They have given us no trouble except the little trouble we had in breaking the men in to using them. (Applause.)

Mr. J. N. LAUDER—On this question of the desirability of using the compound engine as against the plain engine, I am inclined to take rather a conservative view. I agree, to a certain extent, with what Mr. Casanave has said, that until the railroads of this country know more about the compound locomotive than they do to-day, we had better go slow and be conservative and not launch out into the unknown too rapidly. I believe, however, that out of the present experiments being made by the different locomotive builders and by some of the railroads we are going to have a more economical type of engine in a few years to handle our trains than we have ever had before. My observation and experience during the past year, both on our own road and what I know has been done on other roads, lead me strongly to that conclusion. I do not believe that for the present, or for some time in the future, we are going to get any such enormous saving in fuel as some of the figures that are presented would lead us to think, because 35 and 40 per cent., and sometimes more than that, are exceptional cases which ought not to be counted at all. The only way we can get the average and the solid performance is by a more extended use than we have had up to this time. If we cannot get more than 5 per cent., which Mr. Casanave suggests as being obtained under certain conditions, I do not think it will pay any railroad to use compound locomotives. Why? Because in the first place they must necessarily cost something more. The repairs to compound locomotives must be something more. How much the increased repairs would be, none of us at the present time know. We cannot know until three, four or five years' service with those engines in large quantities. The first cost, of course, we do know. We know pretty nearly that they will cost something more than the plain engines—not very much. Now, unless we can get an equivalent in the saving of fuel for this increased first cost and the necessarily increased cost of repairs, there is no earthly object in making the change from the simple engine to the compound. But I believe we are going to get, in certain localities at least, saving enough to warrant us in going ahead and making further experiments in the direction of compounding our locomotives. New England, the Pacific Coast, Mexico and some portions of the Northwest and other isolated parts of the country have to pay enormous sums for their fuel, and the higher the cost of the fuel, of course the greater the gain, if there is any saving in any particular type of engine.

There is one thing that I presume almost all the members of this association hold in regard to this matter, that I am happy to say I think is a myth, and that is that the compound locomotive will not do the range

of work that the simple engine will do. I believed one year ago that compound locomotives for special work must be specially designed for that work. What I mean is a high-speed engine must have a special design for high speed and would not be an economical or serviceable engine on any other kind of traffic. My experience for the past year has modified that opinion quite materially, and to-day I am prepared to say that a compound locomotive can be designed that will have as wide a range of service as the simple engine. The engine that I have had most experience with for the past year and have seen the most of and know the most of its workings, has been used on a variety of work—fast express freight, running at a speed that a few years ago would have been good passenger train schedule speed; on heavy fast passenger trains, both express and local and on suburban trains of eight and ten cars, making eleven stops in nine miles and rather quick schedule. This engine, in each of these different kinds of service has done as good work, and in some cases better work than the plain engine that she was designed to compete with. In only one instance has she failed to do the work as well as the plain engine, and that is very quick work. This comes about from the fact that we took our standard 18 x 24 passenger locomotive, with an ordinary 5½-foot wheel, and simply compounded. My experience for the past year has led me to believe that for any passenger work the wheel should be enlarged. That, I believe, is in the same line with the experience of all other men who have had experience with a compound locomotive. I propose to go farther and build some more of these engines, simply making the change from 5½ feet diameter of wheel to 6½ and increasing the stroke from 24 inches to 26. This, I believe, will give us an engine that will do our passenger work in every respect as well as the plain engine, and I am looking confidently for a material saving of fuel—enough to warrant us in the further use of the compound locomotive. I want to be conservative in my statements made here, because they are publicly made, but I am prepared to say that I believe there is enough in the compound locomotive to warrant all our roads in spending some money to develop the engine and bring out a better type, perhaps, than exists to-day.

There is one thing, however, that I am convinced of and that is that it will take very much more careful designing—very much more able designers to design and build a compound engine than to design and build a simple engine. This perhaps comes about from the fact that the simple engine to-day is almost stereotyped. We are all building about the same thing. It may be a little different in its lines, so that its appearance is different. You would recognize a Baldwin engine or a Schenectady engine by the looks of it. But where is the difference in the material design of those engines to-day? There is very little. With the compound engine there will, undoubtedly, be a variety of types, and as some one has remarked here, it will be a question of the survival of the fittest. When these engines come to be repaired and when they have been used for several years and begin to get old, then will come the crucial test. It will be

a question then whether the engine is actually a more economical machine than the plain engine of to-day. Until that time comes it ought to be true wisdom for the railroads to be conservative but still to push ahead in a conservative way and see if the compound locomotive cannot be developed into a much better machine than we have in average service at this time.

There is one peculiarity about our compound that surprised me, and I presume that same peculiarity exists with all of them ; that is the facility with which they will get a train from a state of rest up to speed, working compound. It took us a good while in experimenting with our engine, to get her so that she was right, but we succeeded finally, and that engine will get a suburban train from a state of rest up to speed fully as quick, and I think as a rule quicker than the plain standard locomotive. Every one, I presume, who makes an effort to bring out the compound locomotive will find difficulty in so arranging the draft matters. We have found difficulty there and I know others have. The quality of the exhaust is so different from that of the plain engine that it needs special appliances and arrangements to bring out the full benefit of this quality in the exhaust. The exhaust from the compound engine must be necessarily very soft and light compared with the plain engine. That is what we have compounded the engine for—to get more out of the steam before it leaves the machine. The consequence is that you do not get the draft on the fire by the action of the blast that you get with a plain engine. The result is that you may have to do a good deal of experimenting before you get the draft just in a condition that will give you the best results. We have been unable to run our compound engine with as large an exhaust pipe as we run our simple engines with. We run our simple 18 x 24 engines with a 4¾ to 5-inch exhaust pipe. We have them running with 5 inches, burning Pennsylvania coal and making plenty of steam. The compound will not run with a pipe of that size. She is running now and making steam very fairly with a 4½-inch pipe. We tried a great many experiments before we brought about the desired results in the matter of steaming. The last thing, and the one that seemed to accomplish more than anything else that we did, was to reduce the diameter of the stack and make it bell-mouthed at the bottom. The reason why it needs a bell-mouth shape at the bottom I apprehend, is that owing to the want of pressure in the escaping steam it spreads very rapidly after leaving the nozzle, and I think that with the ordinary type of smokestack a good deal of that steam strikes inside the smoke arch outside of the exhaust-pipe and thereby makes a whirl of the air and gases in the smokebox, which retards the draft. By making the bottom of the smokestack of a bell-mouth shape it enlarges it to an extent that the steam all seems to get inside of it, and it goes out giving a clean, smooth exhaust and apparently a smooth, clean suction on the fire. With this engine at present we have no trouble at all in making plenty of steam. She carries 190 pounds and will handle our steamboat train of ten to twelve cars on a grade of 44 feet to the mile for six or eight miles, at times with the door open

nearly all the way up the hill—something you can hardly expect with a plain engine.

I want once more to emphasize the fact that I believe novices cannot design to-day a correct and economically working compound locomotive. I believe that it will require very much more accurate working out of the design of valve-motion, steam distribution and pressure than we have been used to giving plain engines. But if we obtain the economy which I believe we can get, we can well afford, if we have not the talent ourselves, to employ such talent as will do the careful designing necessary to build a compound locomotive. (Applause.)

Mr. VAUCLAIN—When I am in order I would like to make some remarks in reply to Mr. Lauder.

The PRESIDENT—You are in order now, Mr. Vauclain, I believe.

Mr. VAUCLAIN—Mr. Lauder has alluded to the repairs of the engine—that the compound engine would certainly require additional repairs over and above the plain engine. I dispute that, and on this ground—that the repairs to the cylinders of the compound engine will perhaps be slightly greater than in the plain engine. In the two-cylinder type, you have the intercepting valve, etc., to look after which will require a certain amount of attention dependent on how it it is made. But there is no doubt that in that type, and in the type that I represent, additional repairs would be necessary to those parts. But have we nothing to offset these additional repairs? What is the life of the firebox of an ordinary locomotive, and what does the life of the firebox depend on? You take the steel which you put in a stationary boiler which will run at 80 to 100 pounds pressure, and it will last fifteen to twenty-five years. You cannot get as much life out of a locomotive firebox. The life of the steel depends on the number of heat units that pass through that steel; in other words, the number of gallons of water that the boiler evaporates.

A compound locomotive does not have to be forced as a plain engine has; the products of combustion are not drawn through the tubes at any such velocity as in the plain engine. There is not the same action of the sparks on the end of the tube or the rapidity of evaporation which causes the water to leave the surface of the steel exposed to the fire.

The service to which these engines can be adapted is another thing Mr. Lauder brings out. He thought that the compound engine had to be especially designed to be adapted to any particular service—for instance, suburban, fast freight, slow freight, or ordinary passenger traffic. We have twenty compound locomotives running on the South Side Rapid Transit Railroad in Chicago. They make from 200 to 245 miles daily, with a few squares between stops. They have harder surface with a 38-inch center to 42-inch wheel than any passenger locomotive on the Pennsylvania Railroad between Philadelphia and New York. They are constantly stopping and starting. As a proof that these engines are equally applicable to all sorts of service I suggest to you to examine into the action of those engines on the Chicago South Side Elevated Railroad.

In regard to the suggestion that compound locomotives should be designed in general with a larger diameter of wheel, I would say that that is not so. It is true that a compound engine will give better results with a large diameter of wheel than with a small, but the same thing is true of the simple engine. If you take a plain engine and give it a larger diameter of wheel, it will give you better results in the same service. If you take an engine with a 62-inch wheel, for passenger service, and then take the same mechanism exactly and put on larger drivers, simply increasing the cylinder power in proportion to the size of the driving-wheels, you will get a far better result and your economy will probably be as great. I think that has been clearly proved not only by engines that we have built running on the Baltimore & Ohio, on the Philadelphia & Reading, and on the New Jersey Central, but also on locomotives that the Schenectady people have built running on the New York Central.

The survival of the fittest was mentioned here to-day in the same manner in which the popularity of the engine was mentioned at the last meeting—that upon the popularity of the compound engine depended the value of the locomotive or the manner in which it was being received by the railroad companies. I do not care to say anything more about the survival of the fittest, any more than I do as to the popularity of the different types.

As to getting at results, Mr. Lauder says that before a company can use compound engines, and adopt them, they must get at results. I would ask this meeting, How are they going to get at results without using these locomotives? The Philadelphia & Reading have taken the right way of finding out about these engines. The Schenectady Locomotive Works are building a lot of engines for the far West, where they propose to get at it in the same way. Any railroad can afford to buy ten, fifteen or twenty compound locomotives and put them on the road, provided they have a large system. Any railroad that has 300 locomotives can afford to try compound locomotives.

As to the starting power, I will agree with Mr. Lauder that a compound locomotive can start equally well with the plain engine. It can start quicker than a plain engine, and why? Because it has not as much steam to get rid of to do that starting as a plain engine has. Mr. Casanave of the western lines of the Pennsylvania road is making some experiments with cylinders having large ports and long valves, and I will guarantee that he will get much better results, not only in starting, but in speed and in getting his trains to their schedule speed, and he will get better results in other directions. He will have less back-pressure at high speed, and short cut-offs and better results, I think, all through.

With respect to special arrangements for blasts, size of nozzle, etc., Mr. Lauder observed that on the compound locomotive we must have such special arrangements, different from what we have on the plain engine. The size of the stack has been changed; the size of the exhaust nozzle is less. I cannot agree with that. I give you liberty to call on any man who is using Vauclain engines in the United States, and he will tell you those

engines are running with the same blast as the simple engines. I think the Schenectady Locomotive Works can bear me out in that. With our system of having four exhausts, it is perhaps easier for us to turn our engine out with the same blast apparatus. Where we have a few cases of those engines running with a few inches less exhaust nozzle, we have fifteen or twenty examples of where those engines are running with a larger exhaust nozzle, with the same elevation of deflecting plate, the same netting, and everything the same all the way through.

Mr. Lauder said we would have to employ the best talent to design the compound locomotives. I want to know of a railroad company that is willing to turn out locomotives that does not want to employ the best talent to design them. The simple engine is as worthy of good designing as the compound. It simply requires to use the brains that they have used on simple engines to build compounds of any type. (Applause.)

Mr. LAUDER—I am sorry that Mr. Vauclain has seen fit to direct most of his argument to me, but I shall not attempt to get into any wrangle with Mr. Vauclain over this matter. I will simply try, perhaps in a feeble way, to answer some of the positions he has taken. I am not prepared to agree with him at all on the question of his repairs. I believe that the position he has taken there is entirely wrong. I do agree with him in his conclusion that the life of the firebox depends largely on the number of heat units that pass through the plates. But he neglects to mention one important feature that has a wide bearing on the life of the firebox, and that is the higher pressures we have to carry or that we do carry on a compound engine. I think that every railroad man who has the care of locomotives will agree with me that the higher the pressure is carried, the sooner the firebox will wear out. That, I think, will go without any question. Now the compound locomotive is carrying higher pressures than we have been in the habit of carrying—in round numbers, 200 pounds. Boilers must be especially designed to carry that pressure safely, and the boilers must necessarily—especially the firebox—wear out sooner.

In reference to the type of compound locomotives, I do not care at this time to get into any discussion with Mr. Vauclain, who is rather aggressive on the question of the different types of compound locomotives—the four-cylinder and two-cylinder types. I am not interested pecuniarily in either type. Some gentlemen here, perhaps, are, and would like to do a little advertising on their own account. Therefore I do not think that we should allow or encourage any acrimonious discussion as to the particular advantages of any special type of engine at this time, because I do not believe we know enough to-day about the compound engine to warrant us in doing what Mr. Vauclain says—to adopt the compound engine to any extent. He describes exactly what I advocated in my former remarks—that the large roads in this country should push ahead and make further experiments with the compound engine, because I am certain that the compound engine will make a good showing and that she has come to stay with us. But the members of this association must not expect any fancy figures in regard to

the economy of the compound. I think the compound engine will finally come down to a point where it will make a saving over the best type of plain engine of somewhere between 15 and 25 per cent. Now if you can get 15 per cent. I believe you are warranted in compounding your locomotives. Possibly in some parts of the country where fuel is high, you would be warranted in using compound engines if they showed a much smaller saving. But taking the country all over, I believe if we can get 15 per cent. economy out of the compound over the best types of plain engines, we are warranted in using the compound engine. My own individual opinion is that we can get more than that. But let us not get our expectations wrought up too high, because we may get a set-back which we do not like. We may be led into error by the statement that we can get 30, 35 or 40 per cent. saving in fuel, which I do not believe we can do.

As I said before, I have no particular controversy with Mr. Vauclain. I agree with him mainly. I did not get up here to advocate any particular type of engine as against the four-cylinder compound. But I want to say it seems to me unnecessary to build and maintain four cylinders on locomotives, with all the attending expense of repairs, when you can get equally good results out of a much simpler form of engine.

Mr. Alonza Dolbeer—There seems to have been a war among the giants in regard to compound engines. I think, with the exception of Mr. Casanave, we have heard from no one who is not a representative of some type of compound engine. I am not a representative of any type. In fact with fuel costing only $1.25 a ton, I am not an advocate of any compounding. In September or October of last year our vice-president sent for me; he wanted to know what my opinion was of the compound engine. I told him I did not know anything—that was the easiest way I could get out of it. I do not know a great deal now. I know a great deal more than I did then. The vice-president told me that he thought it was policy for us, as we were going to buy some engines, to buy some compounds and see what they could do. He believed in them thoroughly. I went to see Mr. Vail, who had a compound engine on the Western New York & Pennsylvania road. I sent a man over there who rode on that engine and got the test of the engine. The result was that we placed an order with the Baldwin people for two of the Vauclain type of compound engines. They came to us in the latter part of December. I have the record of what those engines cost. I wish to say, Mr. President, that here is a sample of the grades which are on the division where these engines were used. (Showing a blue print). When these engines were received, we received in connection with them two engines of the same type—one compound, the other simple. We carry 175 pounds pressure upon the compound engine, while we carry only 140 on the simple engine. I believe if I could get 175 pounds on that simple engine I would get better results—that the comparison would show far better results.

Four of these engines came to us together. I concluded that now is the time to immortalize myself and to know all about them. The result was I took four of the best engineers we had on the road. I put two of

them in charge of the compound and two in charge of the simple engine. We started out in the month of November. We ran only ten days and I found my compound engine showed a saving of 16 per cent. in fuel as compared with the two simple engines. This, bear in mind, was not on the tonnage basis; it was based on the car mileage basis. The tonnage was not included. In the month of December it dropped down to 12 per cent.; in the month of January we got 32 per cent. saving. I thought that that settled it. The weather got bad about that time. Probably I did not give it much attention. Probably there was a good deal of trouble among the men; they do not like compound engines. I do not need to tell you who have compound engines that the engineers do not like them. But the result was that I dropped down in the month of February to 6 per cent. Well, even then there was bad weather. In the month of April I made an arrangement for getting a tonnage test. About the 15th of April we got our record for our March tests. I discovered, somewhat to my surprise, that the simple engines had made a saving of 7 per cent. over the compound engines. (Laughter.) Well, I began to look around to see what the matter was. I observed the man I had selected to run the compound engine had been promoted to road foreman, and he did not give it very much attention. He was the man that had been making the record. I discovered that the other man who had been making the records had been promoted to a passenger train. I do not know who was on the engine; it was pretty hard to tell. I sent for the road foreman and I said "George, do you see that record?" "Yes." I said "Do you see that one over there that shows 32 per cent. saving? You ran that engine at that time, why is it you cannot get that result now?" He said he did not know. Finally we got over this thing and the weather got better and we did improve. The result was that in the month of April, including the first fourteen days, I got fifteen per cent. of economy in fuel from the two engines. In the month of May—a portion of the month of May, I think up to the 20th—I again made a saving of 12 per cent. Now that is what the report has been. Of course I believe that there are many benefits connected with the compound—I will say frankly the principal benefit is the saving of fuel. I do not believe that a road whose fuel does not cost over $1.25 a ton wants to bother with compound engines. In placing an order for eight engines a few days ago, the question was asked whether we wanted any more compound engines; I frankly said no; we had got two. If you will notice (referring to blue print) there is a long pull from here up and then there is a drop over. Now we have one place on our road where there is seventeen miles of a steady pull and a maximum grade of seventy-five feet per mile. I propose to put the next engine we receive on that ground and I do believe we may get some results.

I find complaints; the question of repairs comes in. I do not mean to quarrel with Mr. Vauclain, but I will say frankly right here, you try them awhile and you will find you have repairs to make on them. All these tests are made with twenty or twenty-five pounds more pressure on the compound

engine than on the simple engine. I do not believe it is fair to make the test without putting an equal amount of steam on the simple engine. There is not a man here who does not know that when an engine gets a hard pull the boys screw down the safety-valve a little bit. What do they do it for? To get that load over. How many here have not had examples of engines that have done wonderful service and finally it has dawned upon them that the boys have got about fifteen pounds more pressure on the boiler than you were carrying before. Here is a cut of the tires of two engines I have been speaking of, Engine 56 with a mileage of 17,124 miles, and here is the simple engine, Engine 28, with a mileage of 19,884 miles. That is the wear of the tire. The wear of that I am inclined to think is nearly one-eighth of an inch more. Why? Because of the slip; that is all. Mr. Dolbeer exhibited diagrams of the tires.)

Now, the compound engines have some good points. One day, I said to one of our engineers, the first one that I spoke of as running these engines, "George, how are you getting along with your engine?" He said: "I don't think much of it. I was down on the grade the other day, coming between Ashford and Palmersville, where we have a hard pull on that hill. It was all I could drag; and finally the train broke in two. I made up my mind that I would have to go to the foot of the hill. I backed down the compound, and I pulled that train over the hill and started it over the grade." Speaking only of the Vauclain engine—I do not know anything about the other—I believe there are emergencies where, if you only have a little more power, you would get yourself out of a hole, and I believe the compound engine gives us a chance for that. I have shown you the grades that we have. You will see that that is not a place to use compound engines and get results. However, looking it all over, with coal $1.25 a ton, I will say that I do not want any more compounds at present.

The convention then adjourned until the following day.

SECOND DAY.

The convention was called to order at 9 A. M.

The PRESIDENT—The order of business will be the continuation of the discussion of the report on compound locomotives. I would like to hear from Mr. Soule if he is in the room. But before opening the discussion the secretary will read the report of the Auditing Committee.

REPORT OF THE AUDITING COMMITTEE.

Secretary SINCLAIR read the following report:

Your committee have examined the accounts of the secretary and treasurer of this association, and find that the same agree with the reports presented by these officers.

JAMES M. BOON,
H. N. SPRAGUE,
W. H. LEWIS.

DISCUSSION ON COMPOUND ENGINES CONTINUED.

The PRESIDENT—If Mr. Soule is not in the room, I would call on Mr. A. E. Mitchell, of the New York, Lake Erie and Western.

Mr. MITCHELL—On the 1st of last January we bought from the Baldwin Locomotive Works five compound decapods, weighing about 205,000 lbs. apiece, with cylinders equal to 24 x 28 inches. These engines were bought to place in service on the Delaware division, where we require three engines to get one train up the hill, the distance being 8¼ miles. We figured that the tractive power of one of these engines was equal to that of two consolidation engines. One of these decapods, therefore, would take the place of two consolidation engines on the hill. Since they have been in service they have fulfilled the duty expected of them in a very efficient manner, and we are burning on these engines culm and buckwheat coal, often using pea and buckwheat. But it is a cheaper grade of coal than what we are using on the consolidation engines, which is lump anthracite. One fireman can easily fire that engine, without any difficulty whatever, maintaining 180 pounds of steam. The engines, as I said before, have been in efficient ser-

vice ever since they were put to work January 1st, and we have no cause of complaint of the service we are getting from them. The engines steam freely, and are burning, as I say, a very cheap quality of coal. As for repairs, we have not had compounds on our line long enough to decide what the repairs would amount to, but from what we have seen so far I do not think the repairs are going to be very extensive, although we cannot tell until we have had them in service at least a year. There is one thing, though, on compound engines that was not brought up yesterday, which I think is going to be of advantage to railroad companies, and that is the mild exhaust preventing throwing fire. We find that with the compounds we have in service we are not throwing any fire from the stack, and therefore we are not liable to settle for fire claims for damage to property along the line. That, I think, will be one of the main points in compounding, in addition to the saving of what fuel we will save.

I was very much pleased with the report yesterday from Mr. Gibbs relative to tests on the Chicago, Milwaukee & St. Paul, as I made a great many myself and I know the difficulties they had to contend with. But I think they made as complete a report as it is possible to make, entering into all details that it is possible to enter into and eliminating all errors that you have got to look out for on tests of that kind.

The President—I see Mr. James Macbeth, of the Adirondack & St. Lawrence, who has a number of compound engines in use. We would like to hear from him.

Mr. Macbeth—There is only one clause of the report that I would like to refer to. It is not clear to me, and with your permission I will read it. I have not found the fact to be as stated here—that is, on the two-cylinder compound:

"It will be seen that for the steam distribution used for 100 revolutions, and with the weights of reciprocating parts as built, the simple engine gives a much more uniform pull than the others. Also, that if the compounds were reduced to the same average pressure, the variation would be nearly the same in both. At 150 revolutions, the four-cylinder compound gives the smoothest line and the simple engine is somewhat better than the two-cylinder compound. At 240 revolutions the four-cylinder compound shows the least variation and the single engine the most. These facts are further illustrated by the following table, showing the proportional variation of each engine above and below the mean pressure. It is clear from this, that in this case at least, the rotative effort or returning movement of the two-cylinder compound is not more uniform than that of other locomotives. There is also evidently a definite combination of steam pressure cut-off, weight of reciprocating parts and speed for any locomotive with which it will develop its most uniform pull."

My reason for taking this paragraph up in the report is this—that when I stood and looked at the two-cylinder compound it became a question in my mind whether the engine was going to ride properly or be properly counterbalanced—whether we were going to figure the same pressure on

the one side on the simple cylinder as on the compound. Figures have not been a large part of my experience, which has been practical experience all the way through, so I thought I would find out for myself and I put Mr. Pitkin to a great deal of trouble in running an engine on the Schenectady branch. I had to run her on freight for two or three days. She had a 51-inch wheel—consolidation engine. I made him leave the drawbar between the engine and tender three-eighths of an inch loose. What I wanted to get at was, the side oscillation in those engines. I was satisfied that if his heavy engines had as much side oscillation no one could keep them together. I rode on this engine two or three times. We ran her down hill 30 or 40 miles an hour with that 51-inch wheel; then we ran her 30 or 40 miles an hour without steam. That was my first experience, and I must say it was very satisfactory. She was as straight a riding engine as I ever rode on.

I then went to work and spent three days before I would commit myself to Mr. Pitkin or to our president. They wanted to know my opinion, and I told them I did not have any opinion. So I went to work and made it my business to use up three days in going to Detroit and riding on a ten-wheeler which is a duplicate of the engine down here at the shop, only about 8,000 pounds lighter than the one here. I rode on her on the limited from Detroit to St. Thomas, and I found the very same result that I found on this engine with the 51-inch wheel. She had a 6-foot wheel. She rode as perfectly as any engine I ever rode on. That was my reason for bringing up this point, that I could not understand how they found these results, that a two-cylinder compound did not ride as steadily as a simple engine or four-cylinder compound—something that I had not found. We have got ten on the line —eight under service, the other two here at the depot. We have not found one that does not ride just as straight as any engine ever rode.

Another matter came up yesterday in reference to the exhaust tips. We have found a radical difference all the way through from what was stated yesterday. We are using a 5-inch single exhaust tip, and have had no trouble from steam. Some of our service is very hard—125 feet to the mile—and we never have had a particle of trouble for steam, and we have never had any trouble with coal.

Mr. Mitchell spoke about fires, and I feel safe to say, where we are running through a dense wilderness all the way, that I think our chances of fire are 30 to 40 per cent. less with this engine. This is one of the reasons, I believe, why my people wanted them compounded.

I have just finished a test on the Central Vermont Railroad with one of our compound engines and a simple Baldwin engine that showed a saving of from 30 to 35 per cent. of coal, and the evaporation of water was 8¼ against 5½. We made that experiment on a piece of road 30 miles long, 10 feet up hill, and a grade of 37 feet to the mile; the rest was level.

The PRESIDENT called on Mr. Butler to speak.

Mr. L. M. BUTLER—We are running a compound engine of the two-cylinder type, built for our road by the Rhode Island Locomotive Works.

I have not had it long enough yet to give you anything of value. We have hardly run it two months, so I think the less I say the better.

Mr. F. W. Dean—In regard to the matter of side oscillation of the two-cylinder type of compound, of course I have had some opportunities to observe them, and on the Old Colony compound, when that engine first came out, she had considerable side oscillation. That almost absolutely disappeared upon taking off the cylinder-heads of the high-pressure cylinder and turning off a quarter of an inch and getting more clearance—that is giving more volume for the compression. It is obvious that in that case the disturbing influence would be less. It was noticed that the side oscillation increased as the engine got loose in her housings, but now it is very difficult indeed to see any such oscillation, and if the cylinder head was thick enough there would be no evidence whatever. As I say, you have to look pretty sharply to discover it now. I made the cylinder heads thicker than was necessary for strength, anticipating that I might have the difficulty of excessive compression, and that difficulty can be made entirely to disappear by giving sufficient clearance—I do not mean valve clearance, but I mean clearance in volume between the piston and the cylinder heads, or going up further, to the valve face. The Old Colony engine has in the high-pressure cylinder 11½ per cent. of clearance. That is, the per cent. is reckoned in parts of the piston—the volume swept through by the high-pressure system. I think it would be desirable for it to have about 15 per cent. I think, then, that that is all that remains to be done to entirely do away with the side oscillation that occurs, and to make the two-cylinder compound just as smooth a running engine as the simple engine. On the low-pressure cylinder, if I remember rightly it is about 5¾ per cent. In another design I would increase that very much. I do not know exactly how much, but I could tell very readily from the indicator diagram that I have.

I want to say something about tests that we have recently carried out on express passenger work in competition with a simple engine of the Old Colony standard, and before going into any details of that I want to give my reasons for thinking that in competing with the Old Colony standard engine I had a more difficult engine to work than the majority of simple engines. The indicator diagrams from the Old Colony simple engine show, to the best of my judgment, that there is nothing to find fault with, but that they take as good indicator diagrams as any locomotive that I have ever seen. So much for that.

Now Mr. Lauder makes his cylinders with an air space in front of the steam passages and behind, and also an air space between the steam and exhaust passages. Of course, we all know that that is not common practice; that most cylinders have not those air spaces. Moreover, he also closes up the bottom of the cylinder with a plate of iron and a plate of asbestos on top of that, so there is no opportunity for the atmosphere to circulate about the steam passages. There is no air space on the outside of the passage, that is on the side of the cylinder saddle or the cylinder. In other words the steam passages have air spaces on three sides. It is ob-

vious therefore that the Old Colony standard engine must condense less steam in that way than most simple engines. In fact, I do not know of any simple engines that are so well protected as they are, and that is why I think the Old Colony engines are unusually difficult to beat.

In making our comparisons in the first place, when we made our tests on fast freight which averages a speed of 25 miles per hour and which reached a maximum of 45 to 47, we took an engine which was built exactly at the same time as compound engine No. 235, an account of which appeared recently in some of the papers. The erection of the engine was begun on the same day as the compound and they were finished at about the same time. Both engines had been running about a month before they were tested and we took all due precaution, we thought, to make the comparison proper. We had a piece of misfortune in this respect. We laid out Pocahontas coal enough to test the simple engine. We tested two of them, but I will speak only of 235 because that was the only new engine we tested on that train. We made one or two trips with the compound with that coal. The next day we went to get our coal and found that it had been covered up with Cumberland coal. The boss of the coal shed, I suppose, had no idea of the importance of having all the coal right, but the evaporation fell off 12 or 15 per cent. At all events, the coal was confessedly inferior, and I think all who are familiar with those coals know that there is more heat in Pocahontas coal than there is in Cumberland; at any rate the saving on that train was about 31 per cent.. I think if we had had Pocahontas coal throughout, the saving would have been 38 per cent. The method of making tests was this—the train went from Boston to Fall River, which was about 50 miles, and we began to built a wood fire in Boston and went down to Fall River in the afternoon, banked the fire all night and came back in the morning with 25 long cars. In returning to Boston we let the fire run down below and then dropped it. We made no account of the wood, because I assumed that the wood did not cost much. It was of no particular value to the Old Colony Railroad, and moreover the amount of coal we dropped out of the firebox might be considered fairly equivalent to that. The saving of the coal was based on the actual amount of coal used. The water records were interfered with a good deal by blowing off. Per car-mile the water saving figured up about 13 per cent. The simple engine blew out rather more than the compound did. The compound carried about 175 pounds of steam and the simple one, I believe, a little upwards of 160. I suppose when the compound blew off she blew off more steam to the minute than the other did. I said nothing to the engineer about the proper way to run the engine. I let him drop into his own method and told the fireman to have the engine blow off as little as possible.

After the compound had been running six months in continuous work we began our tests, which we called our efficiency tests, on the express passenger work, two years ago last November. I tested, on the ten o'clock Shore Line train, an Old Colony standard engine, No. 148, which at that time had

been running about a month and had had her valves nicely adjusted to the indicator and was in splendid order ; and a year ago last October we tested that same engine on the Fall River Line boat train after she had been in the shop and it came out in very good shape ; in fact I don't know but that she is just as good as new. The valves and pistons were tight and she steamed well and worked admirably. We also tested Engine 229, which was the regular Fall River Line boat train engine at that time. She had been running, I think, some six months. The compound we tested very recently on both those trains. We have not worked up all the records on the ten o'clock train, but it is obvious that the saving is fully 30 per cent., and those tests were made in the same way that the express freight tests were made. That is, we began our fire in Boston, went to Providence and banked the fire and then returned and let the fire run down as low as we could, precisely as in the simple engines. Then we took the compound on the Fall River Line boat train which consists of anywhere from 9 to 12 cars and occasionally 13. We did not have 13 on any of the tests, but we did have 12, and then again for car mileage the tests showed a saving of just about 30 per cent.

Those tests are rather interesting. They are interesting in this way—they seem to show that the engine is extremely economical in any sort of service. It does not make any difference whether it is hard pulling or light pulling or fast. On these passenger tests the saving in water was about 21 and 22 per cent. In due time, of course, I can work up those tests elaborately and all will be known about that. On this Fall River boat test, however, the results that we now have are the final ones, because they are based on car mileage, I propose to base the other tests on coal and water per hour per horse power.

The other compound engine that I have been connected with is on the Lehigh Valley Railroad. That has cylinders 20 to 30 x 24 and carries 180 pounds of steam. That engine has not shown the economy that the Old Colony has. It was put to a service which I did not expect. It never occurred to me that that engine was to push coal trains up a 96-foot grade at 12 miles an hour. I fancied she was going to be used in a sort of general run in a more level situation. The cylinder ratio is 2¼ to 1. I wish it were 2 to 1. Then, although she might have the same total expansion, it would be divided between the two cylinders. In pushing 30 coal cars up a hill they cut off at 17 inches, and, of course, that is altogether too late. She ought to be compelled to do the work with a cut-off not much later than 12 inches, and the only way to accomplish any thing of that sort when you are limited as to the size of your low-pressure cylinder, which you must do—you cannot stick out beyond your telegraph poles—is to make your high-pressure cylinder larger. You will then get the total expansion that you expect to get anyway well divided between the two cylinders and that gives the minimum condensation with the best results. The Old Colony engine shows a better performance in consequence of having a larger high-pressure cylinder, and she does most of her work with a 12-inch cut-off. She pulls

those trains up a grade 44 feet to the mile, I think. But she does that on schedule time, in 12 inches, with 180 to 185 pounds of steam. Of course, that is a very early cut-off, and of course, it must give very economical results. The engine is certainly highly economical, and while there may be an opportunity for error in water observation there is no opportunity for error in coal consumption.

To return to the Lehigh Valley engine. That engine was tested in competition with a simple locomotive, built, I believe, by the Baldwin Locomotive Works. The simple locomotive has 180 feet of heating surface more than the compound, and that is about 9 per cent. more of heating surface than the compound has. Cutting off at seven inches the engine shows a saving of 16.4 per cent. on the coal and 13 per cent. on water. More recently the engine has been taken down between Easton and Packerton and has made ten round trips—470 miles, I believe, is the aggregate. In making those ten round trips the simple engine was 44.88, and the compound was 42.88 hours. That is to say, the compound did her work in 2.08 hours less time, and the weight of the train was 8,380 tons for the simple and 8,550 for the compound. In other words, the compound not only went faster, but she pulled 170 tons more. The saving was 19.61 per cent. in coal and 23.99 in water. That test I took no part in.

Now, I have been interested in a little computation on the subject of train resistances. That is, assuming that the train resistances were proportionate to the square of the velocity, I computed the amount of coal that the simple engine would burn if she had run as fast as the other; then, again, how much she would have burned if she pulled as large a train as the compound, and the saving comes out 28 and some tenths per cent. Then on top of that I computed the amount of coal which the compound would have burned if she had evaporated as much water per pound of coal as the simple engine did. The simple engine evaporated 6.6 per pound of coal and the compound 6¼. The saving would be 32.4, I believe. Of course everybody knows that such computations as that are not strictly correct, but they must be somewhere near it. For instance, if you get 32 per cent. you might safely count on 28—something of that sort.

I want to say a few words in regard to the principles of designing compound or any other engines, in a general way. In designing a locomotive it is desirable to have the cylinder surface as small as possible. The condensation in cylinders is proportionate, roughly, to the amount of cylinder surface, and by using the smallest number of cylinders you can, you necessarily have the smallest amount of surface. Therefore, speaking in a general way, the engine which has the least amount of cylinder surface will have the least cylinder condensation, and will be the most economical engine. Now, it is perfectly easy in designing a compound engine to so design it that the expansion through the two cylinders will be continuous, and it can be shown mathematically that if the cut-off in the low pressure cylinder is at that point which is determined by the cylinder ratio, the expansion will be continuous through the tube; that is to say, the low press-

ure cylinder will begin its expansion at the pressure at which the high pressure leaves off, and therefore, as many people have supposed, and I presume still do suppose, the objection to the two-cylinder type of engine—that you cannot expand your steam continuously—disappears. It is well known that you can, and it will be so when running at slow speed, so that there is not any drop due to friction in the capacity of the two cylinders. In the two-cylinder engine that can be accomplished exactly by having two reverse levers, one for the high-pressure cylinder and one for the low, and in that case the quadrant for the low-pressure would have a mid-gear notch and a full-gear notch, and one notch in between, at which it would always be worked, and in that way the most desirable results would be obtained. Of course most people will think that it would hardly pay, and I do not think it would myself, to have two reverse levers to accomplish that result.

Now to come back to the matter of cylinder ratio again; if any compound engine has a high-pressure cylinder so small that you are obliged to run three-quarters to full stroke in order to get sufficient steam through the engine to make it do the work, the engine is no longer a compound engine; that is to say, the high-pressure cylinder becomes a sort of steam feeder. It measures off, every time, so much steam to be expanded in the low-pressure cylinder. Such an engine as that cannot give the best results, and the only way, as I said before, to overcome that trouble, is to make the high-pressure cylinder sufficiently large to cut off early. I do not think that for a given amount of work a four-cylinder engine can be designed to do the same amount of work as the two-cylinder engine without having about 50 per cent. more cylinder surface; and, of course, great condensation must follow, and I think that is the great point about the two-cylinder engine, let alone the simplicity of the matter. All mechanical minds certainly admire simplicity just as much as nature does not admire a vacuum.

Mr. William Forsyth—In further discussion of this subject, I think we ought to take up the report of the committee. It is probably the best piece of work on a locomotive test that has ever been presented to this association, and the committee deserve a great deal of credit for their accurate and complete work. In looking over the first part of it I find that they do not ask us to accept their figures as conclusive; they think the subject ought to be continued for future trials; and I am very glad that this committee has been continued for this work. The report covers, of course, only one small phase of the subject, that is, the comparison of the Vauclain engine with a simple engine of similar type, and that is still further narrowed down to a test of this engine in freight service, so that there is still large scope on the subject of compound engines in the matter of testing other types and in testing them in passenger service.

Next in the report is the statement of the number of variables entering into the road test as being enormous. Now that is so, and for that reason I think that the first thing to do, when going into a locomotive test, is to

narrow down those variables as much as possible. I would therefore criticise, to some extent, the manner in which the committee have gone at this work in attempting to apply a long, scientific, accurate test to a freight train in regular service, and to attempt to get in that way average results, and the results obtained by a test of that kind are shown in the report to be extremely variable, and, as the committee themselves admit, it is very difficult to draw any conclusions from it.

If you will refer to some of the tables here you will see what a variation there is. In Table III we have the coal per ton-mile on the same engine varying from .073 to .15, one being nearly double the amount of the other. Then if we put it on the basis of comparison of the coal per horse power per hour, we have 5 pounds in one case and 3.1 pounds in another case, showing that an attempt to get at an accurate test of the locomotive with a train in regular service is not very satisfactory. And in further considering the subject I hope that the committee in making their more accurate measurements will confine themselves to a constant train on a regular schedule as near as possible, and then in order to get fuel economy, as on the basis of what they started out—that is on average service—to simply measure the coal from trains in regular service extending over a long period.

The superior economy given in the final conclusions of the committee to this compound of Mr. Vauclain's, as compared with the simple engine of a similar type, is stated as 6.1 per cent. one way and 9 per cent. another, and a final figure of 7.6 per cent. Then there is a further conclusion at the end of the report, showing 6.9 and 14.1. Taking even these highest figures, say, 15 per cent., I should say that is a very low economy to be obtained from a compound engine in freight service, and that we ought to obtain a much higher economy, and I think it has been found to be a common experience that the economy of a compound passenger engine is very much lower than a freight. So that we should expect from a compound engine of this type, in passenger service, not more than 7 or 8 per cent. During the past month, we have been testing a Baldwin ten-wheel compound engine, which was built for experimental purposes, and we just got through with our test of that engine before I left, and I have the figures relating to that test; but we are testing our own compound engine and our own simple engine with it now, so that I have not the comparative figures, but I will present the figures relating to the passenger test as a matter of interest in supplementing this report, of tests of a similar type of compound in freight service. The Baldwin ten-wheel engine was tested on our Denver express, having extra cars, making it equivalent to a twelve-car train weighing 486 tons, and the average speed was 42 miles an hour. You will see that that is very heavy passenger service. The length of the run was 165 miles. The figures obtained from a number of tests show an average of 5.64 tons of train, including the weight of the engine, per pound of coal, and, put on a comparative basis, eliminating the difference in coal, the figures are 6.64 tons of train per pound of combustible :

TEST OF BALDWIN COMPOUND No. 82,

BETWEEN CHICAGO AND GALESBURGH—CHICAGO, BURLINGTON & QUINCY R. R.

AURORA, June, 1892.

DATE, 1892.	Train No.	No. of Cars.	Mean running weight of Engine and Tank in lbs.	Weight of Cars, in lbs.	Weight of Train, in tons, including Engine.	Water used, lbs.	Coal used, lbs.	Actual lbs. of water per lb. coal.	Lbs of water from 212° per lb. coal.	Lbs. of combustible.	Actual lbs. of water per lb. combustible.	Lbs. of water from 212° per lb. combustible.	Tons of Train per mile per lb of coal.	Tons of Train per mile per lb. of combustible.	Average speed of Train, excluding stops, miles per hour.	Remarks.
June 3	1	11	197,100	726,890	462.0	72,357	14,000	5.17	5.96	11,861	6.10	7.03	5.36	6.33	42.7	......
" 4	6	13	197,100	811,260	504.2	62,400	14,100	4.42	5.08	12,275	5.08	5.84	5.81	6.67	43.1	......
" 6	1	12	197,100	772,920	485.0	......	14,872	......	......	12,472	......	......	5.29	6.32	42.7	Meter broke.
" 7	6	12	197,100	771,350	484.2	72,077	12,650	5.69	6.53	11,076	6.50	7.47	6.22	7.10	43.0	......
" 8	1	12	197,100	819,330	508.2	72,451	15,500	4.67	5.36	12,362	5.86	6.73	5.33	6.68	40.5	......
" 9	6	12	197,100	758,700	477.9	67,837	13,333	5.08	5.83	11,477	5.91	6.78	5.82	6.76	42.0	......
Average...			197,100	776,740	486.9	69,420	14,070	5.00	5.75	11,920	5.89	6.77	5.64	6.64	42.3	

NOTE.—The mean running weight of the engine and tank was assumed to be 218,100 lbs. — ½ (7¼ tons coal + 28,000 lbs. of water).

If the secretary will accept it, I may supplement that by subsequen figures, which we obtained from our own engine for comparison. As the result of more than a year's experience with the two-cylinder compound engine, we have found from the performance sheets an economy in freight service of 30 per cent. over our simple engines of the same type. We are just now testing these engines in passenger service. As the result of our experience with this engine, I would go a little further than Mr. Casanave went in his remarks yesterday, and would say that I would not hesitate at all, if I were to buy locomotives for myself with my own money, to buy compound locomotives for freight service. I believe that the principle is correct, from an engineering point of view, and I have no doubt that it will in time become the prevailing practice. (Applause.)

Mr. J. N. BARR—There is one point in Mr. Forsyth's remarks that I want to object to, and that is where he says that in making tests we want to narrow down the variables. Now it is the variables which make it questionable whether a compound engine is of actual service on a railroad. We know that a compound engine is a good thing where the work is steady and uniform. We know that in marine engineering, we know that in stationary engineering we can design a compound engine that is more economical than a simple engine—somewhat more economical. I have been considerably interested in this matter and I have gone over the celebrated experiments of Hirn in Germany. I failed to find, however, in those experiments that he feels satisfied that you can by compounding obtain an economy of 10 per cent. over the best construction of simple engine; that is where you can compound your engines, adapt them to the work that is to be performed and keep everything uniform. Now it may be that the compound engine is better able to meet the variable requirements of railroad service as a locomotive than the simple engine. It may be that it is decidedly the other way. We do not know. But if the committee in making their tests will start with a uniform load and a level grade and have the wind the same all the time, I do not believe they will give us any information next time that will be worth the paper it is written on. I think that the report of the committee, so far, demonstrates that. The very conflict that is presented there arises from the fact of the variables that are introduced, and every train that we run over the road every day, introduces those variables. Now we have been doing a little too much in the way of eliminating variables in our general tests of other railroad work. We have eliminated variables and then made conclusions from the results that are not sustained in practice. We can take boiler steel and get a good elongation and put it in a box and it cracks; we have not taken into consideration all the variables; and I notice in specifications and so on for materials there is a great deal of that work done, and, in my opinion, it ought to be carefully watched, making conclusions from the tests from which the variables have been carefully eliminated. If we were buying steel to use it for getting long elongation then that test would be a very good thing. If we were buying locomotives to take 800 tons of a train-load over a level road at a certain rate, no meet-

ing points to run fast for, no side track to lie on, then that test would be perfectly satisfactory. But we are not doing that, and that is one point where the difficulty of making any conclusions from these tests comes in.

I like very much Mr. Paxson's idea: take a division, put half the engines compound and half simple, instruct your engineers as carefully as possible, try to remove any prejudices from their minds which they may have, and then let them go and let it tell the story. That is what you have got to do with a compound engine after a while, anyhow. It has got to go in there and make its own record, and it has got to go in there without being covered over with water meters and indicators and speed recorders and dynamometer cards and so on. (Applause.) I think, gentlemen, that that is a very important point. I have made a great many tests of different materials—for instance lubricating oils. Every time that I made a test of lubricating oil and found that it would beat anything that we had completely, when it was put out on a division we did not get good results. I am inclined to think it is the same thing with the compound engine. I do not want to say anything against the compound. I do not know enough. I am in the position of some other gentlemen in this matter; I am a good deal of an agnostic, and I do not want to get my foot in it so deep that I cannot pull it out. Now if we can make an improvement, it is our business certainly to take hold of it. If we are sure that we can make 10 per cent. saving in fuel economy, I believe that we certainly should use the compound—just put it into use as fast as we can. I know that in our section of the country, if we can make 10 per cent. economy in fuel, it is going to pay twice over and three times over any increase in expense for repairs of locomotives. If I were sure of that, I would not hesitate one moment in saying that we are going to put the compounding principle on every engine that we put on the road hereafter. But unfortunately I am not sure. The data that we have got I cannot construe into teaching that thing. Now the committee has had a great many of these points impressed upon them during the tests of the past year. I have been pretty close to this committee and I have seen pretty closely what they have been doing, and it is for that reason that I moved the other day that the committee be continued. They are beginning now to see pretty clearly the difficulties that lie in the way of coming to definite conclusions. They are beginning to see pretty clearly what information they want to ask of the other railroad men in the country, and I say this, that the committee will need the co-operation and the close observation of all other members of this association who have got compound engines, with a close description of the circumstances under which they have been used and the results obtained. (Applause.)

Mr. M. N. Forney—I have a distinct recollection of getting into very warm water at Cape May a year ago in regard to some remarks that I made about an indicator. I have speculated a good deal about my position since that time and the causes of the temperature of the water, and the solution of the difficulty was only presented since I have been present at this meeting, and if this audience would excuse me for telling a little story at my

own expense, perhaps they will understand why that water was raised up to such a high degree. A gentleman was coming down in the elevator in the building in New York in which I have my office and overheard the conversation of some one else, who apparently had just left my office, who made the remark that "that man Forney was a damn fool and always said just what he thought." (Laughter.) I am very much afraid that in this discussion of compound engines I may say just what I think, and I think you may agree with the gentleman—that that is the true character of the person who is addressing you. (Laughter.)

In regard to this compound engine question I am, as Mr. Barr says, an agnostic. I feel that the advantages and superiority of the compound engine have not yet been fully proved, but I think that in taking up this subject we should see clearly what the real question before us is. Now I conceive it to be this: Supposing a railroad company wishes to have a certain number of locomotives, those locomotives to weigh, we will say, 100,000 pounds. Suppose under that condition of things that the general manager of the railroad should go to a builder of compound engines and say to him: "We want you to build engines weighing 100,000 pounds for such and such traffic," and suppose that same general manager should go to some other builder of engines and say: "We want you to build us some simple engines weighing 100,000 pounds for such and such traffic"; and that he were to tell each builder that he would not be obliged to conform to any conditions except those he saw proper; what he had to do was to put 100,000 pounds of iron and steel into the form of a locomotive to give the best service. Whatever advantage the compound system gave, the builder of compound engines could avail himself of; whatever advantage the simple system gave, the builder of simple engines could avail himself of. Under those conditions we have two locomotives in which we may imagine we have the highest degree of efficiency of the two systems.

What do we find under those conditions? In the first place, it is generally acknowledged that compounding increases the weight of the locomotive considerably. Now to the extent to which we increase the weight of the engine it is a disadvantage. The simple engineman, under those circumstances, might take that extra weight and put it into the boiler and get a larger boiler on his simple engine, so as to get greater efficiency from that larger boiler. A trial made with engines of that character would, I think, reveal what are the relative advantages of the two systems. If the system of simple engines has an advantage in weighing less, why surely you have a right to avail yourself of that. In the comparisons and tests and discussions that have been made, it seems to me that in nearly every instance the compound engines have asked for odds in their favor. They have asked to make the engines heavier. They say, "We only put it on the truck." Well, gentlemen, if you will allow me to put the weight of the simple engine on the truck I will get an advantage.

At this meeting we have been presented with some additional evidence on the subject. It is contained in the report of the committee appointed

last year to undertake this test, and it is presumed, and I believe true, that they went at it in an entirely disinterested way, and they have presented us with a mass of figures showing some deductions they have drawn. I have taken the trouble to make a few figures on that on my own responsibility. I have taken, for example, the two curves of tests which have been made with the simple engine with a pressure of 180 pounds, using Braceville coal, and have taken the consumption of fuel per ton per mile, and I find it is .128 per pound of coal. I have taken the compound engine and I have found that it burns .118, making an economy of 8½ per cent. in that group of tests. Eight and one-half per cent. is not a large amount. I would venture to say that any gentleman here present might make that difference in two engines by simply painting the smoke-stack of one sky blue. I think, if you are careful in making the tests of any locomotive it will make a difference of 8½ per cent. If we take the tests made with Braceville coal at 200 pounds pressure—there were no group tests made with 200 pounds pressure with that coal—they burn .104 per ton per mile, showing an economy of 19¼. Now that is asking odds of the simple engine. It is no indication of the superiority of the system.

Now we will go down to the Pittsburgh coal. The simple engine there used 200 pounds pressure and burned .088 of a pound. The compound engine burned .078, showing an economy of 11.5. Now, Mr. Chairman, the question is whether that amount of percentage is sufficient to justify us in using the new system. I made some very rough figures in regard to that, which, perhaps, can be remembered without being printed in any form. I think most of the gentlemen will agree with me that an ordinary engine burns about $2,500 worth of coal a year. Fifteen per cent. of saving would amount to $375. To get that saving you have a locomotive that costs about $750 more than a simple engine. To be on the safe side you should allow ten per cent on that additional investment. You therefore have a saving of $300 in the course of a year where the coal does not exceed $1.50 a ton. I think you will all agree with me that it is a very easy matter to use up $300 on extra repairs of a locomotive engine, and therefore I have taken the saving at fifteen per cent., which is considerably higher than the average saving shown by your committee.

There is still another question which comes in here. One of the most important things in locomotive engineering, or in building locomotives, is to get locomotives that will do the work. It is not a question of getting locomotives that will make a good indicator diagram. It is not a question of getting locomotives which will show good results from very careful tests when all these variables are brought into consideration. The business of a locomotive is not to burn variables—it is to burn coal. (Applause.) The important and overwhelming question, the one which your general managers, your directors, everybody, asks you is, How long can you keep your engines in service? The most important question is the number of miles you can run in the course of a year and the number of cars you can haul. The question of hauling cars is of infinitely more importance than the saving of

coal. Now, is it probable that we can get an amount of service out of the compound engine which is equal to that of the simple engine? If the compound engine is not able to give as many miles service in the course of a year as the simple engine, it will condemn the system.

Having spoken on that side of the question, I should like to say something on the other side.

Of course we are all interested in having the most economical engine. If on careful tests we find that the compound engine will make a saving anything like that claimed by its advocates, of course we will all have to use the compound engine. But I think it becomes this association to go very slowly in the matter, to be very careful what they do, before they commit their companies to the use of a system which has not had sufficient time to be thoroughly investigated. It strikes me, therefore, that a good plan would be to appoint two committees on this subject, one consisting of the advocates of the compound system, to get up a compound engine of the very best character they can find, and the other consisting of gentlemen like Mr. Barr, who are agnostics on the subject, and let them get up the very best simple engine that can be found, and then have a competition of these two engines and let the advocates of the two systems have charge of those tests. I think in that way we would be more likely to get at the real facts of the case than we are in the tests which have been made. It is unfair to try a man for his life without giving him counsel. It is unfair to try the simple engine before the public without giving it counsel. Therefore I think there should be a committee to stand up for the simple engine. It may be that the simple engine can be improved still more than it is.

You will observe that in these tests that have been made, in the burning of Pittsburgh coal the compound engine shows considerably less saving than in the burning of Braceville coal. Now it certainly would be a disadvantage to the compound engine if it is not able to burn all qualities of coal. It reminds me a little bit of the young doctor who was called upon to attend a patient who was in the last stages of consumption and desired very much to have some corned beef and cabbage. The doctor thought this patient would die very soon, and perhaps it would hasten his death, so he allowed him corned beef and cabbage. The patient began to improve and finally got well. Soon after the doctor had another patient of the German persuasion who was suffering from stomach trouble, and who, in the absence of the doctor, took corned beef and cabbage and died. Thereupon the doctor made this entry in his book: "Corned beef and cabbage cures consumptive shoemakers and kills dyspeptic Dutchmen." Now I think if the compound engine will not burn all kinds of coal it is not suited for the business of our roads. (Applause.)

The President—I have been requested to call on Professor Woods.

Professor A. T. Woods—Taking up some of the points in the report which have been discussed, reverting to the diagrams of the rotative pressures, in the first place, those diagrams were obtained, as it states in the report, from indicator diagrams which are also given in the report. I am

responsible for the diagrams, and I would say that I did not know how they were coming out, because when I began, I simply took what seemed to us, and what seemed to the chairman of the committee to be good, representative indicator cards from those two engines. Then we worked them out with the weignts of reciprocating parts as given us by the builders, and these are the results we found. They are good examples of what the locomotives did under those circumstances. As there are only nine or ten cards figured altogether, it is not safe to draw general conclusions, and they are given simply for what they are worth as illustrations. They do seem to show that the claim for a much more uniform rotative effort of the two-cylinder engine is not substantiated. In Table 7 of the report, it seems to me, the best illustration of what the engine did under those circumstances are the lines which give the tests with the compound at 200 lbs. and the simple engine at 180 lbs., with Braceville coal. There were eight or nine tests, I think, with each one, and those averages are given in coal per horse-power hour and water per horse-power hour, 22.9 one way and 17.5 the other. The water per horse-power per hour was 25.7 and 14.8. That seems to me the most fair figure to use in that case. The general averages for the different kinds of coal and different pressures are, it seems to me, not valuable Now, of course, some of the saving there is due to the higher pressure—how much it is difficult to say. In order to get some idea of it, I made a hasty calculation. Saying that we were cutting off at about half stroke with 180 lbs., you raise the pressure to 200 lbs. and cut off sufficiently early to take advantage of it, there is a saving of something like 10 per cent. In that case, if that would hold, it would reduce our saving on the compound, in both cases, in coal and water to about 10 per cent. Of course that would be due to compounding alone. It is not possible to make an exact calculation of the loss by condensation in the two cases. I do not include that at all. It was, I say, simply a rough estimate.

Another point which is mentioned in the remarks on the results of tests—the saving in coal per ton-mile and water and horse power, it seems to me that the horse-power basis is the only one on which we can figure. An examination shows that there is a great difference whether we use the ton-mile basis or horse-power basis, and as the horse power takes into consideration the speed and the ton-mile does not, it seems to me that is the proper figure to use.

Referring to some remarks which have been made in regard to the different types of engines, the cylinder surface exposed, etc., I think Mr. Dean's statement does not include everything; that while in the two-cylinder engine we may have less surface exposed to condensation we also have a smaller ratio between the cylinders and, therefore, less possible expansion, so that you may lose on one and gain on the other. I do not think it is safe to say that an engine with a large high-pressure cylinder is necessarily better on that ground.

I want to ask Mr. Forsyth in regard to the boiler pressure that he used in the tests that he gave?

roads where coal is cheap, so that their approval upon those roads means satisfactory possibilities for our Western master mechanics who have to contend with dear fuel.

Before entering upon a discussion of the problem, as it appears to your Committee to-day, they beg to present all the information they have been able to collect, in the nature of tests or figures; this is embodied in the following:

SYNOPSIS OF INFORMATION OBTAINED FROM RAILWAY COMPANIES.

The following information is abstracted from answers received by your Committee to a circular sent to various members of this association. The circular requested, particularly, practical data bearing upon experience with compound locomotives in actual service. It was stated that your Committee hoped in this way to obtain information which would shed some light upon the probable net value of compounding locomotives. They further desired "to bring out as fully as possible the advantages as well as the defects of compound locomotives, not only as regards fuel economy, but as to all other elements which go to make up a successful machine, from an operating as well as a motive-power point of view."

Quite a large number of replies were received, in the majority of which members were obliged to state that they had no experience with compounds; in others, information given was so meagre that no conclusions were deducible at a distance. Your Committee also reports absence of replies from some of our members who are known to have a considerable number of compounds in use. The following are abstracts from those giving fullest information, with comments upon the results. Your Committee hope that unwarrantable deductions will be corrected by members present representing the roads quoted, for in no case was it possible for the circulars to cover a statement of all local conditions governing the tests.

Northern Pacific Railroad.

Performance sheets record of five months' service in freight with one compound and one simple Baldwin mogul.

Engines of same dimensions, the compound having 20 pounds higher steam pressure.

Engines in service two years, having run about 60,000 miles. Records are for the last 17,000 miles of the above.

No figures for train loads given.

Compound was found to use 20.3% less coal per engine mile than the simple, and 18% more oil.

They also give results of comparative tests on ten trips, as follows:

Percentage train hauled per pound coal, 22.2;

Percentage water evaporated per pound coal, 11.3;

both in favor of the compound.

No data given for cost of repairs, and no opinion ventured as to probable relative standing. State they have had trouble with irregular wear of crossheads and guides.

Above submitted by them without further remarks.

Norfolk & Southern Railroad.

Performance sheets record of two months' service, with small mileage (2,400 for 35 runs), in local freight, of one compound and one simple Baldwin mogul. Engines of same general dimensions, except that compound has 10,000 pounds more on drivers (13.3%), and 20 pounds higher pressure than simple.

Compound was new, while simple was two years old.

Car mileage and average cars per train were about the same (latter 35).

Compound was found to use:

24% less coal per engine mile,

22.2% less coal per car mile,

23½% more oil than the simple.

Gives cost of repairs per mile run to be 24% more for compound, but as the compound was a new engine this figure appears to your Committee of no value.

State that their general observations indicate increased cost of repairs to compound on account of extra number of rod and piston packings, construction of crossheads and presence of special parts.

Results in passenger runs from one month's performance sheets are given for two other Baldwin engines; the simple being an eight-wheel engine ten years old and the compound a heavy

and I do not want to give the results. But if any one will take the strains that are thrust on the crossheads, he will find that they are something enormous.

In conclusion, I will say that when any one talks about fancy tests, that this test which was taken with as little expense as possibly could be on the Chicago & Milwaukee road, having cost them over $6,000, I think it would be unreasonable to ask any more of the railroad companies than they have already given us.

Mr. J. DAVIS BARNETT—Since I last spoke on this subject, I have had no personal experience with the compound engine, and therefore I need not detain this convention. But I would like to ask the chairman of the committee to explain for me one item on Table VII. I have not had time to fully analyze this report. I was trying to get some understanding of it last night. Referring to Table VII, lines 27 and 28, I take it that experiment 28 is put in close comparison with 27 there, showing that the simple engine, with a higher pressure than the compound, gave an economy in coal consumption. That is how I understand 27 and 28. Going further down on Table VII to lines 42 and 43, which are there bracketed together, I infer that they are put in comparison one with the other. I see that the simple engine, having 200 pounds pressure, is negative there, so far as economy is concerned. Do I properly understand that table to read that the simple engine having 200 pounds pressure had a superior coal economy to the compound with low pressure, and yet when it comes to compare that simple engine with itself that she was not as economical using 200 pounds pressure as she was in using 180?

Through the president, I ask the chairman of the committee for information on that point.

The report is so full of interest that I feel sure that we are all going to take it home and analyze it and get to the bottom of it. It has very seldom been my lot to put my hand on so large a mass of valuable information, so carefully, accurately and conscientiously worked out. (Applause.)

Mr. GEORGE GIBBS—Mr. Barnett says that he has not had time to fully digest this mass of information, and I want to say that the committee also has not had time to do it fully. This table is made out to give all possible combinations of the two engines at the different pressures and under different conditions, and the economies as shown are exactly results of the figures on those different bases.

Mr. Barnett is perfectly correct in saying that engine 822, which is a compound, showed a loss at 200 pounds. I will say this, generally,—that the compound engine was not suited to haul the trains that were offered to it at 180 pounds pressure, and it is hardly fair to the compound to take the results at that pressure.

As to the simple engine at the two different pressures, that line on east bound trips certainly does show a negative economy at the higher pressure for the simple engine. In line 30 the simple engine gave an increase of 13.7 per cent. on raising the pressure.

My own impression, generally, is that we cannot conclude that there is any economical effect by raising the pressure of the simple engine. I am also not able to conclude that there is any economy in raising the pressure on the compound engine, provided she is suited to do her work at the lower pressure. The gain of economy by raising the pressure of the compound, I think, is largely due to her being more suited to handle the business at the higher pressures, and not the increase of cylinder economy.

I would like to say a word regarding some of the remarks which have been made in connection with this paper.

Mr. Barr—I desire to ask a question on this subject. I understand Mr. Gibbs to say that in lines 42 and 43, Engine 822 was not as economical at 180 pounds as at 200 pounds.

Mr. Gibbs—No ; not as economical at 200 pounds as at 180 pounds.

Various opinions have been expressed by the members in a kindly spirit regarding this report, and I wish to say a little more emphatically, that I personally had no idea of the difficulty of this contract that we undertook. We started to make a complete test of the compound engine. We attempted in the report to express our inability to cover the subject fully. Mr. Forsyth remarked that in making a test of this kind, our first object should be to eliminate variables. I take the same position that Mr. Barr does on this subject—that we want all the variables in there, if we desire to get at the economy which the engine will show in road service. The only variables that we had to leave out was the variable manner of handling the engine by the men. We selected the most careful crews that we could get—men who would work their engines consistently. But that does not represent—and we so stated—the economy that we would expect on a division, for either the simple or the compound. I have no doubt that we got better economy out of both engines than we would if we put them in everyday service, and we did not attempt to predict what economy would result from everyday service, year in and year out. That is something we are not able to show without a very long-time test. We did try to show the economy of the principle, but we left in all the variables which might properly belong to such a test.

Mr. Forney stated, as I understood him, that we want an engine that is able to burn all kinds of coal. The reports show that the compound is able to burn all kinds of coal. The compound engine gained 19 per cent. in evaporating efficiency by the change from Braceville to Pittsburgh coal. She showed less comparative economy than the simple, because the simple gave less economy in changing. The figures offered this morning for the economy of the compound engine do not bear out the conclusions of the committee in this respect. I am not able to explain that discrepancy, but I will say positively that I do not believe that, in our engines on our road, there is any more economy than is shown by the conclusions given by our committee. That represents the maximum to be obtained from those engines. It is an undoubted fact that we can pick out trips that will show, individually, larger economy, but, for all around service, it is not in it. (Applause.)

Mr. SETCHEL— I want to say that I have had no experience whatever in using compound engines, and I think an expression of opinion without some experience is not of very much value. But, of course, I have, and am entitled to my theoretical opinion, although I do not care to give it at this time. The Pittsburgh Locomotive Works, which I have the honor to represent, have no compound locomotive in service, but I want to say that we expect, as the saying is, to be in the swim. We are constructing a compound locomotive, and we expect, by giving an increased heating surface and grate surface, and very much larger boiler, and other advantages, to show a saving equal to any of our competitors.

Mr. D. L. BARNES—In respect to the tests given in this report, I would like to say that they represent sixty tests, made in the most accurate manner that any tests have ever been made in, and if we cannot draw conclusions from these sixty tests, then the use of all fine apparatus for testing locomotives is in a pretty bad way. I think, if any one will examine carefully all the conditions that are so well given in this report, he will be able to draw some valuable conclusions. If not, the only thing to do is to have a long-time test under running conditions.

A statement was made here about the saving on a certain engine on the Adirondack road, and I would like to call attention to that statement, becanse it emphasizes some of the analyses I have made of other tests. There was a saving of 30 per cent. in coal per ton-mile. That is the final saving, but in the firebox there was a saving of 45 per cent. Now, the other 15 per cent. must have been lost by the compound system, if logical reasoning can be applied to the results given us. The same paradox can be found from a great many tests that have been published.

If you subtract from the saving per ton-mile the saving in the firebox, you get a negative result, which will indicate that if you should improve the combustion in the simple engine it would beat the compound engine. There is something wrong in such results, I believe, and that is clearly shown by the results the committee have given on these diagrams.

Another speaker has claimed 30 per cent. economy for the compound engine, but in that case he had 25 or 30 pounds greater boiler pressure, and did not mention it. I do not believe that is fair to the simple engine.

As far as the theoretical saving of the compound engine is concerned, it is not due to the lesser amount of cooling surface, but to the decreased range of temperatures in the cylinders, and that should be borne in mind. Most of the compound engines have greater cooling surfaces, they have larger ports and the surfaces of the ports are very large in proportion to the capacity of them.

About the oscillation of the compound, it seems to me that it is all dependent on the method of balancing. On the elevated road in Chicago, where, of course, an engine must be well balanced, we have twenty engines running, and they run as steady as any simple engine could, up to a speed of 40 miles per hour. If it is true, as the committee has stated, that these tests shown on the wall are the result of comparing a simple engine, with

sufficiently large cylinders, with a compound engine, with too small cylinders, I think it is a point that should be borne in mind in making analyses. Perhaps the compound would have shown better if it had cylinders the proper size.

Mr. C. E. SMART—The subject seems to have been very thoroughly discussed, but in justice to myself and the Michigan Central, I will say a few words. I have been asked a great many times why it is that the Michigan Central, having had two compounds, did not continue to build compounds, or to buy them. Now there are several reasons why, and the principal reason is this: We find that in order to get the very best results from a compound engine, it is necessary that the engine should be worked to her maximum capacity. I believe that is the experience of those who have tested the compound engine. Now that being the case, if we, on the Michigan Central, were to have fifteen or twenty compounds, they would be running in one direction, perhaps, heavily loaded, and in the other direction their load would be reduced one-half or two-thirds. In the one case they would make a gain and in the other case the gain would be neutralized on the return trip. That is one reason. Another reason is that we are about to go into a heavy business; the World's Fair is coming on, and we are using every effort to get our power into the best possible condition, and for that reason we do not wish to put compound engines, or a great many of them, into service and into the hands of inexperienced men.

Now I have never claimed to exceed 12 to 18 per cent. saving for the compound, even under the most favorable circumstances. A short time ago we made a test on the Canada Southern—or rather it was worked up by the train department, and it showed a saving of 16 per cent. There was a saving in water of only 7.4 per cent. as compared with 16 per cent. in fuel. That test extended over a period of some four or five days and covered 892 miles. There were forty-five cars on each train and the cars were passed over the scales and weighed and the weights given.

There were some remarks made here yesterday to which I would like to refer. Mr. Lauder stated his experience in regard to the exhaust—the size of the exhaust. I can agree with Mr. Lauder in almost every statement he made, excepting where he spoke of using a smaller exhaust. On our simple engines we used 4½, in some cases 4¾; but in the compound we have no difficulty in using 5¼ inches. That gives the compound engine an advantage. We worked with nozzles from 4¾ to 5¼-in.

Mr. Vauclain made the remark in regard to the repairs that might be necessary on the intercepting-valve that there might be a necessity for repairs there which would make additional expense over the simple engine, but in other respects he could not see that there should be any great increment. So far as engine 284 is concerned, which we have had running between two and a half and three years, all I can say, regarding the intercepting-valve or the repairs to it, is that I have every reason to believe there is an intercepting-valve in there, because I examined it on the floor in Schenectady and I presume it is still in there, but I have never seen it since,

and it seems to me it has been doing just as good work as it ever did. I cannot understand why it should not. There is a valve as nicely adjusted as any engine with its packing, and it does not move once while the piston of the engine moves five hundred thousand times, and why there should be any difficulty there I cannot see.

As regards the life of the firebox in compound engines, our experience is where we have taken the set of tubes out of the simple engine while the compound has been going on without any leak, or call for change.

Mr. R. H. SOULE—I think that the Norfolk & Western Railroad, during the last six weeks or two months, has really had a very exceptional experience in this matter of compound locomotives. In the early spring, the managers of the Norfolk & Western property found it necessary to add to their locomotive equipment in connection with a contemplated extension of the line. In that block of additional equipment there were to be fifteen passenger engines. The different builders were invited to compete. We submitted plans and specifications of the best type of engine we had for the service, a ten-wheel passenger engine. The result was that the Baldwin Locomotive Works was awarded the contract for those fifteen engines. But in sending in their bid they very slyly inserted alternatives there. They gave us a price on a simple engine such as we asked for and on a compound engine such as they would like to put in. After a good deal of consideration it was agreed that we should take five of these simple engines at once and have them made compound. The Baldwin people agreed to rush them through their shops and give us the benefit of them as soon as possible. We were then placed under instructions to give our opinion on this question in one month after these engines had been put in service, in order that it might be decided what the remaining ten engines should be. So we put the engines to work and placed them in competition with an equivalent number of simple engines of the same type and in exactly the same service.

The compounds were generally similar to the simple engine, but the Baldwin people were authorized, of course, to make such changes in the design as were necessary to introduce the compound principle and to secure any legitimate advantages, and taking advantage of that liberty which we gave them, they increased the strength of the boiler—not its diameter, not the number of flues, not the proportions of the firebox—they increased the strength of the boiler so that the pressure might be run up to 185 pounds against 160, I think it was, that we were carrying. But incidentally they also wanted to increase the diameter of the driving wheels in order to get the corresponding benefit of slower piston speed and slower valve speed and better distribution and action of the steam; and in introducing the larger wheels it was necessary to lengthen the engine a little—ten inches, I think; and, necessarily, that ten inches of length was added to the flues. Those were the conditions. We did not consider the ten inches increased length of flues any advantage to the compound whatever, because I think it has been clearly demonstrated long ago that the large proportion of evaporation due to flues occurs at the firebox end. Therefore the increased

advantage which the compound engine enjoyed from the greater length of flues may be disregarded.

I will say, in the first place, before I give the results of the test, that we distributed these engines on the two general divisions of the railroad so as to get results from two independent sources. The results were watched by careful men and reported, they simply reporting the performance of the engines, the trains that they hauled and the total amount of coal consumed, but not taking any account of the water evaporation. We also, during the last week of this period, had a close test made of performance throughout —coal consumption and water evaporation, and we received reports from those three different sources and averaged the results. We found a saving of 20 per cent. in fuel and 10 per cent. in water as compared with the simple engines, and as we had to make a decision on the lot, we recommended that the additional ten engines be compound. With us it was simply a question of compound against simple engines. We had no option whether it should be the Baldwin compound or any other. But we took the Baldwin compound, not because it was the Baldwin compound, but because it was a compound engine, and we thought we had demonstrated and we were safe in assuming that there would be an advantage to the railroad company in using the compound.

Now as regards the discussion here, it seems to me that there are two factors in this matter which have not been reckoned with sufficiently. One of them has been touched on by the last few speakers. It was alluded to by Mr. Barnett, I think, and then again by Mr. Gibbs and Mr. Barnes; and that is the fact that in advancing the pressure you carry in your boiler you reach your limit in the simple engine long before you do in the compound. My impression is that it is on record somewhere on pretty good authority that the most economical point of cut-off for the simple engine is between three-tenths and four tenths of the stroke. If you advance the cut-off you lose, simply because you do not take the benefit of expansion. If you cut off earlier than that you increase your condensation in the cylinder. That is, you condense water in the beginning of the stroke at high pressure and re-evaporate at the end of the stroke at low pressure, and you lose the difference in those pressures, and the only possible advantage in increasing the working pressure on the simple engine will be the possibility of cutting off earlier, and I think that Mr. Gibbs' figures and the general information which is on record on this subject lead us safely to the conclusion that we have about reached the limit of economy in the working pressure of the simple engine. I think common practice has run those pressures up to 160 lbs., and I doubt very much whether we can advance them much further in the simple engine. Therefore I want to answer the point made by Mr. Forney. He claimed that he believed that in every case where the compound engine had been given the trial it had been given some advantage, and I think he included that. I do not agree with him on that. I think the advantage of carrying higher pressures should be given to the compound engine every time.

Another thing has not been alluded to here at all, and that is this: If it is true that one of the advantages of the compound engine is that she will do the same work with less fuel, then the converse of that must be true, to a certain extent—if she will do the same work with less fuel, she will do more work with the same fuel. I do not know that we can prove that a compound engine can be made, under forced combustion, to consume just so much coal as a simple engine of the same size. I do not think we can prove that. But I do believe there is an advantage in there which is going to appeal very strongly to our transportation officers. We have looked at it entirely from the motive power standpoint and the standpoint of economy of operation as expressed in pounds of coal consumed per unit of work done. But beginning with the engineers--if engineers, train despatchers and superintendents gradually find out that they can get a little more work out of a compound engine of given proportions than out of a simple engine of the same proportions, they are going to be a battalion in favor of the compound. It can get that advantage in two ways: If it is deemed that it is legitimate to count on increased pressure in the compounds, assuming that the piston areas are the same, then we can assume that the compound will start more carefully from a state of rest than the simple engine. On the other hand, if it is true that the compound engine will do more work with the same fuel, then, having started the train, the compound engine will also move it over the road faster, because you can make your steam go farther. You can either use it at a decreased cut-off for the same speed, or at the same cut-off for an increased speed. When the transportation officers of our railroads wake up to this thing and find that they are enjoying an advantage of that sort, I anticipate that they will enlist themselves on the side of the compound engine and that you will have an almost irresistible influence that is going to carry you right along in that direction.

During this discussion I have been reminded of what is on record in the history of science, and that is when away back in the thirties, Dr. Lardner, one of the most distinguished scientists of that day in England, proved conclusively, to the satisfaction of the English public, that it would not be possible to build a boat large enough to carry enough coal to take it across the Atlantic Ocean. You all know how completely that has been refuted. I feel very much as if the future historian of this association, in digging up the records, might say we were a second edition of Dr. Lardner if we went too strongly against this improvement. I feel it in my bones that it is just as sure to come and displace the simple engine as possible. Instead of feeling any reluctance in tackling this problem, I think that we ought to throw all our energy into it.

Mr. Lauder—I move that the discussion of this subject be closed. Motion carried.

The next question taken up was the report, read by Mr. Forney, of the Committee on the

STATUS OF THE CAR COUPLER QUESTION.

Among the duties imposed on your Committee was that of representing this Association at a meeting of another committee, appointed by the Railroad Commissioners of the various States to frame a law for the better protection of railroad employes from accidents and danger. A meeting of the latter committee was held in the city of New York during last winter, and representatives of the different railroad associations were invited to appear at the meeting.

Three members of your Committee were present at that meeting. The position which was taken and argued by your representative on that occasion was that any legislation by Congress to compel railroad companies to adopt any kind of automatic coupler was at present inadvisable. Owing to the great diversity of opinion among those who represented various associations at that meeting, the committee which was instructed to frame the law to be presented to Congress could not agree, and consequently no such law was framed, although several of the individual members of that committee submitted proposed laws of their own to Congress.

The Committee of the M. C. B. Association of Coupler Standards and Limits, with which your Committee was instructed to co-operate, have made a report at the recent meeting of that Association, a copy of which is submitted herewith. This report, it is thought, has substantially the scope which your committee was expected to cover in its report. The report referred to was received by the M. C. B. Association, and its recommendations were adopted. In addition thereto, another committee, consisting of Messrs. J. M. Wallace, John Gibbs, Wm. Garstang and E. Chamberlain, was appointed to make tests of couplers and report at the next meeting. The Secretary of that association was also instructed to communicate with the Interstate Commerce Commissioners and ascertain whether that commission could have the tests made at the Watertown Arsenal.

The Executive Committee of the M. C. B. Association have procured gauges for the preservation of the contour lines and thickness of the metal of the M. C. B. coupler, and these gauges are to be submitted to letter ballot for adoption as standards of that association.

La Crosse Division. TABLE NO. 2. *Date, July, 1892.*

CHICAGO, MILWAUKEE AND ST. PAUL RAILWAY.—PERFORMANCE OF TEN CLASS "D" LOCOMOTIVES.

Engine No.	Engineman.	Miles run.	Total coal.	Miles to 1 ton coal.	Pounds coal per engine mile.	Repairs per mile, in cents.	Miles to pint of machine and valve oil.	Miles to pint of valve oil	Standing of Engine No. 827 (compound).			
									Miles per ton of coal. 1st greatest.	Pounds per eng. mile. 1st least.	Repairs. 1st least.	Miles per valve oil. 1st least.
818	Dwyer......	4,498	203.5	22.10	90.48	62	13.97	53.54	3d.	3d.	10th.	10th.
819	O'Connor....	4,123	150.2	27.45	72.85	1.30	10.88	54.97	......	......	......	......
820	Cowper......	4,239	144.1	29.42	68.09	1.37	9.16	51.07	......	......	......	......
821	Barrett.......	4,217	167.8	25.13	79.58	1.00	12.33	61.11	......	.....	......	......
822	Gebhardt....	4,163	163.4	25.48	78.50	57	13.78	56.25	......	......	......	......
823	Fidlin	4,263	195.8	21.77	91.86	90	12.50	51.98	......	......	......	......
824	Clarey..... ..	3,995	170.0	23.50	85.16	1.11	12.22	49.32	......	......	......	......
825	Gregg.......	4,537	192.5	23.57	84 85	1.59	14.05	56.71	.....	......	......	......
826	Gale.........	4,348	165.0	26.35	75.90	69	14.59	58.62	......	.....	......	.....
827	Rusch.......	3,270	122.6	26.67	75.00	2.73	10.09	34.06	......	......	......	......
Average, excluding engine 827........		4,266	172.5	24.47	80.81	....	12.61	54.84	.....	......	.	......
Saving for engine No. 827............ ...		......	......	7%	7%	....	......	......	......	.....	......	......
Saving for engine, simple............		......	......	......	......	....	-25%	61%	......	......	......	......

La Crosse Division. *Date, August, 18 2.*

TABLE No. 3.

CHICAGO, MILWAUKEE & ST. PAUL RAILWAY.—PERFORMANCE OF TEN CLASS "D" LOCOMOTIVES.

Engine No.	Engineman.	Miles run.	Total coal.	Miles to 1 ton coal.	Pounds coal per engine mile.	Repairs per mile, in cents.	Miles to pint of machine and valve oil.	Miles to pint of valve oil.	Standing of Engine No. 827 (compound). Miles per ton of coal. 1st greatest.	Pounds per eng. mile. 1st least.	Repairs. 1st least.	Miles per valve oil. 1st least.
818	Dwyer.......	3,462	154.0	22.48	88.96	2.59	11.03	50.91	1st.	1st.	1st.	10th.
819	O'Connor....	3,811	152.4	25.01	79.97	2.43	13.37	54.40	......	......	......	.....
820	Cowper......	4,540	176.0	25.79	77.53	95	9.30	45.30	......	..	......	.....
821	Barrett......	4,113	165.3	24.88	80.57	1.46	12.39	56.34	......	......	......	......
822	Gebhardt....	4,499	171.0	26.31	76.01	1.29	12.64	48.90	......	......	......	......
823	Fidlin.......	4,140	187.4	22.09	90.53	1.32	11.86	52.40	......	......	......	......
824	Clarey.......	4,279	173.4	24.68	81.04	1.03	12.37	53.40	......	......	......	......
825	Gregg......	3,732	169.4	22.03	90.74	1.78	10.31	48.47	......	......	......	......
826	Gale.........	4,429	188.6	23.48	85.05	1.00	12.37	50.33	......	......	......	......
827	Rusch.......	4,354	148.5	29.31	68.21	94	12.84	38.87	......	......	......	......
Average, excluding engine 827.........		4,112	170.8	24.08	83.38	....	11.74	55.48	......	......	......	......
Saving for engine No. 827..............		......	......	22%	11%	...	9%	......	......	......	......	....
Saving for engine, simple............		......	......	.....	......	....	......	43%	......	......	......	......

new steel of the same make, and also better than some new steel of other makes.

The conclusion of your Committee, from tests made, is, that steel which stands a bending test at a blue heat, does not necessarily give material which can be depended on not to crack in service.

It was suggested that iron plates, on account of the tradition that they were less liable to crack in the firebox, would resist fracture at a blue heat better than steel. Your Committee accordingly made a number of experiments of the same kind with the samples of the best iron boiler-plate made in this country and England, the result being that at a blue heat the tendency of the iron plate to crack was decidedly greater than is the case with steel. This, in the opinion of your Committee, corroborates their position that the bending test at a blue heat is not a criterion on which to base an opinion of the suitability of material for firebox purposes.

The tests of steel at a blue heat, as referred to above, do not really introduce any new information so far as the fact of the liability of steel or iron to crack at a blue heat is concerned, but the tests, as shown, would seem to imply quite clearly that material which will stand this test is not necessarily good material, and it also illustrates the importance, in handling any material of this kind, of working it either cold or at a red heat.

The samples tested were heated in muffles in a specially prepared furnace made of fire-brick, drawing of the same being attached to this report and marked Figure 1. The temperature was taken by a pyrometer in the lowest and hottest muffles, and by thermometers in the muffles occupying higher positions. It was found that by this means a very equal temperature could be maintained, and your Committee believes that the figures, as given in the report for the temperature of the pieces when tested, is very nearly correct. When the pieces were removed from the muffles, they were quickly bent at right angles, the time consumed being about thirty seconds, after which the bending was continued by hammering the ends together until the fracture began to manifest itself.

ETCHING.

A number of tests were made by etching new and old steel, the etching mixture being diluted sulphuric acid. Some quite in-

teresting results were obtained from this. The etchings of all the new steel showed a decided uniformity of structure in the same pieces, except where laminations occur, but there is quite a difference in the appearance of the etchings of different brands. Some

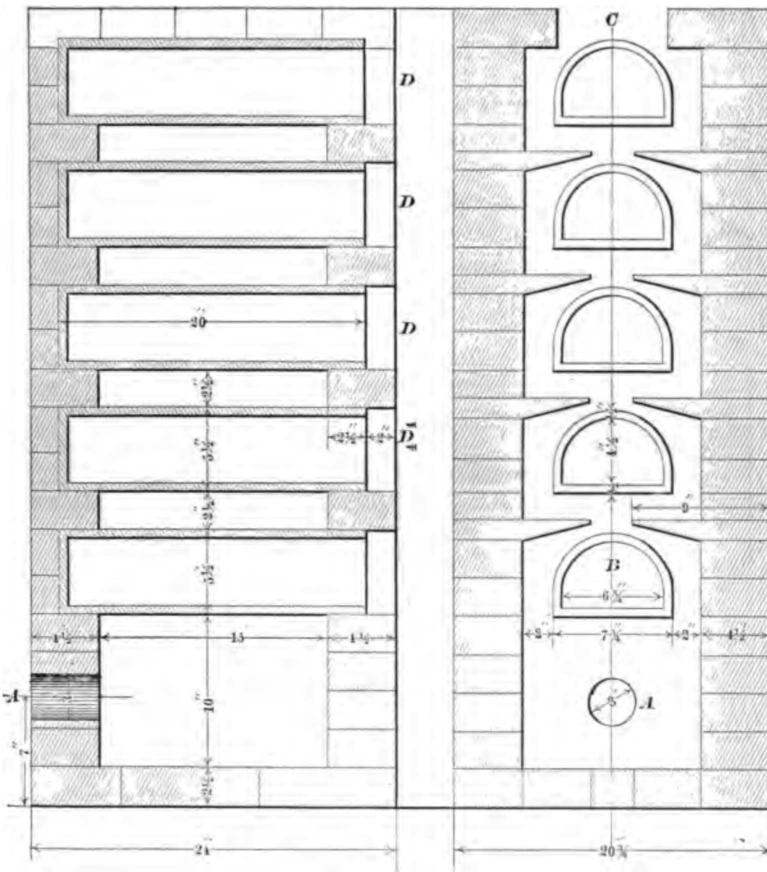


FIG. 1.

were much more quickly attacked by the etching fluid than others, and appeared to be coarser in grain. The most interesting results were observed in etching steel which had been in service in fire-boxes. In several samples of steel three-eighths of an inch thick, there was a decided difference shown in the structure

of the middle portion of the steel as compared with the two outside edges, there being a zone through the center of the piece about an eighth of an inch wide which the etching fluid attacked most actively. The outer eighth of an inch on either side showed but little more effect than new steel, while the inner eighth of an inch was spongy and appeared to be an entirely different material. The print of the most pronounced sample, which was only two years in service, is attached to this report, and shows clearly the phenomenon described. See *A*, Figure 2.

A number of tests were made of old sheets varying in service from 80,000 to 600,000 miles, and some of the pieces which had only made 80,000 miles showed more of a disorganization of the interior of the sheet than the samples which had made 600,000 miles.

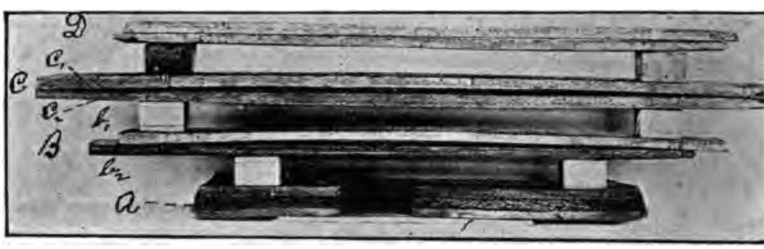


FIG. 2.

Unfortunately, it was not possible to obtain etchings of these sheets when they went into service, but your Committee is of the opinion that this phenomenon would not have been observed in the new sheets. Further tests should be made of new sheets, and of the same sheets after they have been in service, to establish this point.

The spongy interior of several of these pieces was carefully removed by a narrow tool, leaving the outside and inside of the sheets, about one-eighth of an inch in thickness, intact. Of these two pieces, the one next the fire sprung inward towards the fire about one-sixteenth of an inch in a length of eight inches, forming an arc of a circle; the one next the water remaining almost perfectly straight.

This phenomenon, perhaps, indicates a permanent expansion of the sheet on the side next the fire.

Your Committee was of the opinion that in cutting out the central portion of the sheet it might have been strained by the action of the tool, and to verify this point a piece of new steel was cut and split in the same manner; this showed no camber whatever.

It has been claimed that annealing a sheet would restore it to its original condition; with this object in view your Committee took a piece of the same sheet, carefully annealed it by heating to a red heat, then placing it between two pine boards and allowing it to remain until cold. The center was then cut out as in the other cases, and the result was the same as with the piece not annealed. This apparently clearly demonstrates the fact that annealing an old sheet of steel does not restore it to its original condition.

If there is a similar set or permanent expansion in the ends of the stay-bolts next the fire, it may be that it somewhat accounts for the cracks radiating from the stay-bolts, which are so frequently found in steel sheets.

It is impossible to say how much influence the apparent internal disintegration described above may have on the life of the sheet, but it was observed that some firebox sheets which had made a service of 600,000 miles did not show as much susceptibility to the action of the etching fluid as some other sheets which had made a service of only 80,000 miles, and which then cracked badly.

The idea has been advanced to us that the chemical actions of the fuel and waters may have a decided influence in shortening the life of firebox sheets, but we have made no investigations to determine this.

The facts as stated above in brief are as follows:

1st. There is apparently a disintegrating action taking place in the center of the sheet.

2d. The side next to the firebox seems to be permanently expanded, giving it a camber when set free by being sliced off from the rest of the sheet.

3d. Annealing after service does not remove this phenomenon.

La Crosse Division. TABLE No 8. *Date, January, 1893.*

CHICAGO, MILWAUKEE & ST. PAUL RAILWAY.—PERFORMANCE OF TEN CLASS "D" LOCOMOTIVES.

Engine No.	Engineman.	Miles run.	Total coal.	Miles to 1 ton coal.	Pounds coal per engine mile.	Repairs per mile, in cents.	Miles to pint of machine and valve oil.	Miles to pint of valve oil.	Standing of Engine No. 827 (compound). Miles per ton of coal. 1st greatest.	Pounds per eng. mile. 1st least.	Repairs. 1st least.	Miles per valve oil. 1st least.
818	Henerty	3,775	203 6	18.54	107.86	1.94	11.87	53.16	7th.	7th.	6th.	10th.
819	O'Connor . .	4,135	164.3	25.17	79.46	2.32	12 23	62.57	......	......	......	......
820	Farrington...	4,157	187.8	22.14	90.35	1.60	11.36	53.98	......	......	....	......
821	Barrett.......	3,705	155.2	23.87	83.77	1.80	13.28	66 16	......	......	......	......
822	Gebhardt.....	3,159	127.1	24.85	80.69	4.55	9.03	50.14	......	......	......	... ..
823	Rusch	4,187	187.6	22.32	89.61	2.76	9.20	52.33	.....	......	......	......
824	Clarey	4,260	188.5	22.60	88.49	1.03	11.36	60.85	......	......	... ..	......
825	Gregg	3,454	165.1	20.92	95.53	5.30	9.62	52.33	.....	......	......	......
826	Gale.........	2,104	81 2	25 91	77.18	30.61	9.80	55.36*	......	......	......	....
827	Fidlin........	3,177	181.7	22 25	89.89	2.80	10.18	36.94	......	......	......	... ..
Average, excluding engine 827.........		3,660	162.3	22.92	88.10	....	10.86	56.32	......	......	......	......
Saving for engine No. 827.......		...	......	......	. ....	....	......	......				
Saving for engine, simple		......	......	3%	2%	....	7%	52%				

* Had heavy repairs, $1,054.51.

La Crosse Division. TABLE No. 9. *Date, February, 1893.*

CHICAGO, MILWAUKEE & ST. PAUL RAILWAY.—PERFORMANCE OF TEN CLASS "D" LOCOMOTIVES.

Engine No.	Engineman.	Miles run.	Total coal.	Miles to 1 ton coal.	Pounds coal per engine mile.	Repairs per mile, in cents.	Miles to pint of machine and valve oil.	Miles to pint of valve oil.	Standing of Engine No. 827 (compound). Miles per ton of coal. 1st greatest.	Pounds per eng. mile. 1st least.	Repairs. 1st least.	Miles per valve oil. 1st least.
818	Henerty.....	2,985	147.0	20.31	98.49	9.50	11.57	56.32*	2d.	2d.	6th.	10th.
819	O'Connor....	4,272	235.1	18.17	110.06	96	14.29	61.02	......	......	......	......
820	Dwyer.......	3,131	159.5	19.63	101.88	2.49	12.38	63.89	......	......	......	......
821	Barrett.......	3,914	190.6	20.54	97.39	1.15	12.43	59.30	......	......	......	......
822	Gebhardt....	3,120	145.8	21.40	93.46	1.43	9.57	45.88	......	......	......	......
823	Rusch.......	3,987	185.9	21.45	93.25	1.47	11.52	57.78	......	......	......	......
824	Clarey......	3,875	166.5	23.27	85.93	1.06	9.31	45.58	......	......	......	......
825	Gregg.......	3,585	182.5	19.65	101.81	7.87	11.24	60.76†	......	......	......	......
826	Farrington...	2,826	148.6	19.02	105.16	12.71	10.79	65.72‡	......	......	......	.....
827	Fidlin.....	4,008	181.7	22.06	90.66	1.52	9.54	37.81	......	......	......	......
Average, excluding engine 827.........		3,483	173.5	20.38	98.60	....	11.46	57.36	......	......	......	......
Saving for engine No. 827...............		......	.. . .	8%	8%	....	......	......				
Saving for engine, simple............		......	......	......	......	...	20%	52%				

* No. 818 had heavy repairs, $283.82.
† No. 825 had heavy repairs, $282.19.
‡ No. 826 had heavy repairs, $359.39.

La Crosse Division. **Date, March, 1893.**

TABLE No. 10.

CHICAGO, MILWAUKEE & ST. PAUL RAILWAY.—PERFORMANCE OF TEN CLASS "D" LOCOMOTIVES.

Engine No.	Engineman.	Miles run.	Total coal.	Miles to 1 ton coal.	Pounds coal per engine mile.	Repairs per mile, in cents.	Miles to pint of machine and valve oil.	Miles to pint of valve oil.	Standing of Engine No. 827 (compound). Miles per ton of coal. 1st greatest.	Pounds per eng. mile 1st least.	Repairs 1st least.	Miles per valve oil. 1st least.
818	McGeen......	2,074	120 5	17.21	116.20	37.26	9.51	46.68*	3d.	3d.	5th.	8th.
819	O'Connor	4.049	202.5	20.00	100.02	1 32	14.36	55.46	......	......	......	......
820	Farrington...	3,730	194.2	19.21	104.12	1.32	10.45	54.85	......	......	......	......
821	Barrett.......	......	......	......	......	....	......	......	......	......	......	......
822	Gebhardt	......	......	......	......	....	......	......	......	......	......	......
823	Rusch	3.728	165.5	22.53	96.03	1.17	9.53	49.05	......	......	......	......
824	Clarey	3,647	179.7	20.29	98.54	96	11.88	53.63	......	......	......	......
825	Gregg	1,864	74 3	25.09	79.18	19.60	11.51	50.37†	......	......	......	......
826	Dwyer.......	3,512	195.4	17.97	111.27	62	11.63	53.21	......	......	......	......
827	Fidlin.......	2,885	139.9	20.62	96.98	1.96	7.95	32.05	......	......	......	......
Average, excluding engine 827.........		3,229	161.7	20.33	100.77	....	11.27	51.89	......	......	......	......
Saving for engine No. 827...............		......	......	1%	4%	....	......	......				
Saving for engine, simple.............		......	......	......	......	....	42%	62%				

* Engine No. 818 had heavy repairs, $752.87.

† Engine No. 825 had heavy repairs, $365.51.

La Crosse Division. *Date, April, 1893.*

TABLE No. 11.

CHICAGO, MILWAUKEE & ST. PAUL RAILWAY.—PERFORMANCE OF TEN CLASS "D" LOCOMOTIVES.

Engine No.	Engineman.	Miles run.	Total coal.	Miles to 1 ton coal.	Pounds coal per engine mile.	Repairs per mile, in cents.	Miles to pint of machine and valve oil.	Miles to pint of valve oil.	Standing of Engine No. 827 (compound). Miles per ton of coal. 1st greatest.	Pounds per eng. mile. 1st least.	Repairs. 1st least.	Miles per valve oil. 1st least.
818	McGeen	3,682	199.5	18.45	108.36	1.65	7.75	47.20	1st.	1st.	10th.	4th.
819	O'Connor	4,301	218.1	19 72	111.04	84	14.62	53.09				
820	Farrington	3,990	172 4	23.14	86.41	1.27	12.35	51.81				
821	Barrett	4,117	175.5	23.46	85.25	1.29	10.45	56.29				
822	Gebhardt	3,596	156.7	22.95	87.15	1.98	11.27	52.88				
823	Cowper	4,463	238.9	18.68	107.05	1.27	13.25	58.72				
824	Clarey	4,707	213.3	22.07	90.63	1.07	11.02	54.73				
825	Gregg	1,915	81.0	23.64	84.59	14.73	50.21	25.53*				
826	Washburn	4,732	201.4	23.49	84 76	1.42	15.88	70.92				
827	Fidlin	1,674	67.8	24 69	81.00	44.59	13.95	55.80†				
Average, excluding engine 827		3,945	184.1	21.73	93.92		16.31	52.35				
Saving for engine No. 827				14½%	14%							
Saving for engine, simple							17%	7%				

* Had heavy repairs, $961.75.

† Had heavy repairs, $746.43.

TABLE No. 12.

CHICAGO, MILWAUKEE & ST. PAUL RAILWAY.

General average of performance of ten Class "D" engines, La Crosse Division, for eleven months, June, 1892, to April, 1893, inclusive.

Engines.	Miles per ton of coal.	Saving per cent.	Pounds of coal per engine mile.	Saving per cent.
Average of nine simple engines.....	21.99	....	92.52	.....
One compound engine—all engineers	24.34	10.7	83.72	9.5
Compound with Engineer Rusch—5 months..........................	27.21	17.5	74.04	15.0
Average of nine simple engines—same months....................	23.15	.....	87.44	.....
Compound with Engineer Fidlin—6 months..........................	21.94	4.3	91.78	5.1
Average of nine simple engines—same months....................	21.03	.....	96.76	.....
Simple engine with Engineer Rusch—5 months..........................	21.27	2.1	95.74	2.0
Average of eight other simple engines—same months.............	20.83	.....	97.56	.....
Simple engine with Engineer Fidlin—4 months..........................	21.91	5.0	91.26	4.4
Average of eight other simple engines—same months.............	23.18	.....	87.45	.....

TABLE No. 13.

CHICAGO, MILWAUKEE & ST. PAUL RAILWAY.

Showing cost of five engines for period of fifteen months (about 55,000 miles run each), including all repairs from time engines were received from builders until receiving general shop repairs.

	Engine 821.	Engine 822.	Engine 825.	Engine 826.	Engine (compound) 827.
Miles to 1 ton of coal........	22.40	22.05	22.42	19.45	24.84
Miles to 1 pint of valve oil....	53.56	47.52	52.65	46.69	39.52
Miles to 1 pint of machine oil.	19.74	18.68	19.21	17.87	20.95
Repairs per miles in cents...	4.01	3.91	4.82	4.22	4.26

TABLE No. 14.

Pennsylvania & Northwestern Railroad.

Date.	Engines.	Average mileage.	Average cost per mile run, in cents.				Average saving for compound.		Average cars handled.	
			Coal.	Material.	Labor.	Total.	Coal.	Total.	Loaded.	Empty.
May, 1892....	Nine simple......	1,883.1	6.47	1.54	1.55	9.58	....	....	327.6	364.1
" "	Nine compound..	2,062.2	4.74	.27	.65	5.89	24%	38%	358.7	379.2
June, "	Nine simple......	2,079.3	6.74	.87	.69	8.28	....	....	397.6	397 5
" "	Nine compound..	2,087.3	5.09	.35	.65	6.09	24%	26%	345.1	359.7
July, "	Nine simple....	2,001.0	6.24	.66	.50	7.40	....	....	344.0	360.0
" "	Nine compound..	1,722.0	5.17	.38	.50	6.04	17%	18%	292.0	320.0
August, "	Nine simple......	1,878.1	6.78	.41	36	7.57	....	....	314.1	349.7
" "	Nine compound..	1,767.6	5.39	.45	.77	6.63	20%	12%	297.2	350.2
September, "	Eight simple.....	1,456.1	5.39	.82	1.57	7.68	....	....	230.4	246.6
" " ..	Eight compound.	1,459.7	4.33	.67	1.13	6.16	20%	19%	247.8	287.2
October, "	Eight simple.....	1,609.6	7.13	1.10	.59	8.82	....	....	291.5	324.1
" "	Eight compound	1,660.0	5.70	.53	1.19	7.42	20%	16%	227.7	357.3
November, "	Eight simple.....	1,664.0	6 58	1.03	.81	8.42	....	....	285.0	315.0
" "	Eight compound.	1,791.0	5.38	.43	.74	6.54	18%	22%	284.0	354.0
December, "	Seven simple.....	1,837.7	6 29	1.09	.67	8.05	....	....	356.0	383.0
" "	Seven compound.	1,953.0	6.24	.58	.61	7.43	00%	7%	306.0	337.0
January, 1893....	Eight simple.....	1,315.0	7.58	.60	1.03	9.21	....	....	190.0	228.0
" "	Eight compound.	1,421 0	6.40	.49	.78	7.67	15%	16%	192.0	231.0
Average, 9 months	Simple...........	1,747.1	6 58	.90	.86	8.33	....	....	304.0	329.5
" "	Compound......	1,769.3	5.40	.46	.78	6.65	18%	20%	283.4	330.6
Saving in favor of	Compound......	....	18%	49%	9%	20%	....	....	.....	.....

been compiled, giving results appearing on the regular monthly performance sheets.

The tables show performance of ten engines, in which the compound, No. 827, appears. These engines are of the same class and were all built by the Baldwin company, and put in service in February, 1892. It has been thought advisable to give these results in more detail than those from other roads, for the reason that your Committee have full knowledge of the conditions and can speak more intelligently of the same than in other cases. Tables Nos. 1 to 11, inclusive, give monthly performance; the column for "Repairs per Mile" gives running repairs, except in cases noted, where figures are abnormally high, where they include "general shop repairs," which are charged to month in which they occurred. These repairs obviously destroy the month to-month average cost of "Repairs per Mile" for the entire series; for final comparison in this respect see Table 13. At foot of each table have been averaged the figures for the nine simple engines and a comparison made with those for the compound. Four columns are also given, which show the standing of the compound on the basis of best performance under the several headings; this comparison is, obviously, a rough one only. The names of enginemen are given, as it will be seen the men are unequal in capabilities, for the purpose of drawing attention to the fact that the compound (No. 827) was run by two different crews, one of which was probably the best and the other the worst on the list. The influence of these different men on performance of the compound is partially shown in Table No. 12. Here the average saving in coal for the entire eleven months for the compound is seen to be 10.7%; for the five months when it was run by Rusch, he saved 17.5% over the average of the other engines for the same period; for the six months, when compound was run by Fidlin, he saved but 4.3% over average of the others. In the last four lines of No. 12, it will be seen that Rusch is apparently a better man than the average of the others by 2.1%, while Fidlin is worse by 5%. Of course, too much reliance cannot be put upon such a comparison, but it would seem that something must be added to the results shown by the compound with "both engineers" to place it upon the plane of an *average* performance. It may be further noted that Fidlin took the com-

pound in the latter half of the period, when it was nearly ready to be "shopped." Up to the date of this report, five of the engines had been shopped, and in order to obtain some idea of the comparative cost of the compound for repairs at a period when all required general overhauling to put them into first-class condition again, Table No. 13 has been compiled. The results shown will be referred to further on.

REMARKS UPON INFORMATION COLLECTED.

It will be seen that the foregoing information, collected from various sections of the country, tend to indicate *on their face* almost unanimously, a varying but large economy of fuel for the compound when compared with simple engines. Your Committee feel obliged to state that they are not willing to accept all these results at their face value in contributing to a final solution of the question of fuel economy. Presumably the tests were submitted as being more or less comparable, and yet in some cases they are obviously only remotely so, and not one word of explanation accompanied them. Your Committee, therefore, respectfully submit the figures to the wisdom of the association, with few individual comments.

Referring to last year's report, in the final paragraph the prediction was ventured that with friable Western coals an average economy for compounds in freight service should approximate 17%, this figure being the maximum obtainable upon the average, with engines worked in the best manner, in perfect physical condition, and in what may be called characteristic freight service of the country. It is interesting to examine the further figures here given for the same engines used for basis of last year's report, and which have an additional year's service. (See report from C. M. & St. P. Railway and Tables 1 to 13.) The first fact to be drawn from the figures is that, while the averages of nine simple engines probably give a very just and close approximation to the operating cost of that class of engines for the given conditions, a comparison of same with only *one* compound can hardly be called conclusive ; and yet the results are valuable, taken together with the committee tests of last year, and tend to confirm the latter, particularly as an attempt was made to eliminate the effect of "individual running" by changing enginemen.

Mr. Charles Blackwell—I, certainly, for one, protest against the statement made by Mr. Smith. I think that every steel manufacturer knows that without chemical analysis it is impossible to tell what he is getting, and if he does not know what he gets, no one knows what the result will be. It is necessary, as said before, that the physical test should be combined with the chemical test. I think it would be rather a difficult matter for Mr. Smith to say that the two sheets or the two fireboxes that he referred to received exactly the same treatment and were under the same conditions. I think it would be a very difficult matter for him to say so, and, unless the steel received exactly the same treatment, it is improper to draw conclusions or comparisons.

Mr. Barr—I would like to ask a question, somewhat in the line of Mr. Smith's question. If a steelmaker is making steel from material obtained from certain ores in certain localities and has been manufacturing steel right along in that way for years, and has demonstrated to the public that he is turning out a first-class quality of steel, can he then call in a chemist to analyze a deposit of ore from some other section and be satisfied that he is going to give his customers as good an article as he did previously, or the same article?

Mr. Dolbeer—I would like to ask if Dr. Huston is here. I would like to hear his ideas in regard to that.

Mr. Barr—I would like to have that question answered. There are a good many steelmakers here, and it is important.

Dr. Huston (Lukens Steel Co.)—I will answer that question, gentlemen, in this way—that no man can tell entirely by the chemical analysis what results he may get. It is only that he must have a certain chemical analysis to produce a certain article, but that analysis will not always produce that article. There is one particular principle that I think all chemists will acknowledge, and that is the purer the ore, the softer it is, and the more rapidly it will wear and the more subject it is to chemical action, and I do not know but that the committee have run against that snag. It seems to me that in steel for a firebox the carbon ought not to be reduced too low. But I am sure that Mr. Wellman will bear me out in this—that every manufacturer will not only analyze the stock he uses, but of every heat of steel that he casts he will send a sample ingot into the chemist's laboratory and have it analyzed, and he will send a sheet into the physical laboratory and get a test of that. There is a difference, I know, as to the tensile strength; of that, you gentlemen will have to be the judges. It is like the old woman's pudding. We make the pudding and you eat it, and the proof of the pudding is in the eating.

Mr. Smith—I would like to give Mr. Huston and Mr. Wellman each a piece of the same steel and ask them what the trouble was with it. It made less than 60,000 miles when it was cracked from one end to the other. Here are the samples I refer to, and here is the chemical analysis. (Mr. Smith handed the samples and the analysis to Dr. Huston.)

Mr. Wellman—I should say (answering Mr. Barr's question) that an

analysis was only an indication. If from our experience the analysis showed that the ore would make good steel, I should be inclined to try a small batch of it. I am not a chemist, but I think we could tell without fail from the analysis of an ore, if the chemist would give us a complete analysis; but he does not do that; they do not tell us more than half the story.

Mr. BARNES—As a member of the committee I would like to say a little about this report. Our chairman has said that he believed an etching will show more about steel than a chemical analysis. I believe he is right if he will go further and say that an etching will show the mechanical structure of the steel—that is to say, whether it has laminations or cracks. But so far as showing whether the steel is good for a firebox, or boiler, or tank-plate, I do not see how an etching can show that; because an etching of one good solid sheet of steel will look very much like an etching from any other good sheet of steel.

Referring to Figure 2 of the report, the result there shown is exactly what would take place if there was a very bad lamination in the plate. I heard of a case the other day where a brick had accidentally gotten into an ingot and they made a boiler-plate of it, and when they put it into the fire-box it cracked. The edge of it looked not much different from the picture A. I would hesitate myself to say—from what little I know about it—that the etching of a firebox-plate shows that it deteriorates in the center, or anywhere else after service. As far as the chemical analysis of steel is concerned, the chemists give us the exact amounts of the different elements in the steel, but they do not say, except in the case of carbon, in what way these elements are combined. For instance, they refer to "combined" and "graphitic carbon." One of those is a chemical combination with iron; the other is a mixture. But, in the case of sulphur, silicon, manganese and phosphorus they do not say whether it is one phosphate of iron or another. But it is well known that one phosphate of iron will differ from another as much as iron differs from steel.

This question of lamination has been avoided by the committee, yet I do not see why it is not a very important one. We avoided it, I suppose, because we could not say anything about it that was valuable. In one case, one laminated sheet cost a locomotive builder last year $2,000. I suppose the steelmaker replaced the sheet for $15—a very small percentage of the total cost. In making specifications of steel sheets for fireboxes, something should be done to discover whether there are laminations in the sheet or not. Etchings on the edge will not show what is in the middle of the sheet. Some one has proposed a bending test, but you cannot bend a sheet to see the cracks and then use it afterward. Perhaps the only way you can protect yourselves against laminations is to hold the makers of the steel responsible. Steel has, in one case at least, been guaranteed for two years against lamination, with the understanding that the steelmaker should pay the cost of replacing bad sheets. If there is a lamination in a firebox-plate at first, it will always be there; if there is none when it is made, then there will never be any.

the economical results obtained from simples in long service should lead us to hope for the same of compounds, at least at this stage of the question, when it has been shown that they will run 50,000 miles and over without serious impairment of efficiency.

Turning again to fuel economy, your Committee believe the greater number of thinking and observing men in the profession to-day believe the compound will save coal under certain conditions; some of these men deny that these conditions can be fulfilled in practical railroad service. Others say that the fuel economy will be wiped out by increased cost of other supplies and repairs. One condition referred to above is that the compound is not as powerful a machine as a like simple, and must be provided with a starting-valve to allow it to work simple in starting and on hills; this valve, it is claimed, will wipe out the economy, because it will be habitually used, not so much from carelessness of enginemen as from the fact that the operating department will find out they have a more powerful machine at their disposal when the occasion requires, and will load the train until the habitual use of the valve becomes a necessity. From one point of view it may be with justice said that no one would expect economy under such conditions; but it can be with equal justice affirmed that master mechanics will have to meet this condition. It, therefore, behooves designers to strive for equal power for the compound without the use of such a valve.

As to the other question, of repairs, your Committee have brought results as nearly up to date as practicable, and are not disposed to go far behind the figures in offering a definite conclusion. The compound is a new machine, it is subject to certain crudities of all new designs; these will constitute defects which will cost more for maintenance than the perfected points of the older type. But no evidence has been advanced to show that these defects cannot be remedied by time, and this part of the question resolves itself to consideration of extra cost of maintenance of additional parts in the compound. As the fuel saving possible is not an excessive amount, it points to the conclusion that we must strive for the greatest simplicity and greatest reduction of number of such parts in the new type, if we are to expect a net saving in service.

While upon this point, your Committee wish to call attention

to the unwise policy of locomotive builders in so many cases advocating compounds of entirely different type and dimensions from the simples formerly used, thus making comparison difficult and producing an experimental type which is possibly not well suited to the work. All are surely interested in quickly disposing of the question of availability of the new principle—a solution retarded by a multiplicity of designs.

Your Committee feel they have already trespassed too far upon the attention of the association without adequate return. They have, however, as yet said nothing of the use of compounds in passenger service. The results of tests for this service are both meagre and inconclusive. The conditions are such that the compounds have less chance for profitable employment here than in freight; the difficulties of design, at least, are greatly increased; as, for example, in the valve motion, where the high piston speeds and short cut-offs in high-pressure cylinder produce unmanageable back pressure.

Your Committee, therefore, offer tentatively the following opinions and suggestions:

1st. The compound is suitable for a variable class of freight service.

2d. Its range of economy in such service is fully as wide as that of the simple.

3d. Its increased coal economy over the simple in the average freight service of the country will be found to lie between 10 and 15%, when in good running condition and handled with intelligence.

4th. A well designed compound should not be more difficult to keep in a serviceable condition than a simple; that is, its regularity of performance should not be less than with the simple.

5th. The four-cylinder compound will cost more for valve oil than a simple.

6th. The running repairs of a four-cylinder compound will be somewhat more than for simple; for a two-cylinder compound, they should not be more; the final comparison for repairs is undetermined.

7th. The net running cost of a compound will be less on many roads than of simple, the figure depending upon the design, cost of fuel and other local conditions.

8th. In passenger service the availability of the compound is undetermined.

9th. Complicated designs of compounds are not likely to prove successful or economical. The prevailing forms of starting valves, in use in this country, are especially noted as being too complicated—certain valves employed abroad seem to have more commendable points.

10th. Attention is called to the necessity of long time tests and averages of a considerable number of exactly similar engines of both types to properly establish the status of the question. In such tests the influence of higher pressure for either type should not be allowed to complicate the results, as the effect of the highest modern steam pressures on economy of the simple is undetermined.

GEORGE GIBBS,
WILLIAM H. LEWIS,
PULASKI LEEDS,
JAMES MEEHAN,
T. W. GENTRY,
Committee.

On motion the report was received.

DISCUSSION ON COMPOUND LOCOMOTIVES.

The PRESIDENT—Gentlemen, the question of Compound Locomotives is before you for discussion. I sincerely hope that you will take hold of it and discuss its merits with those of the simple engine in a most earnest and scrutinizing way. Let me ask your earnest attention to this subject to-day.

Mr. S. M. VAUCLAIN—In glancing over the report returned by the Committee on Compound Locomotives, I notice that the majority of the engines taken into consideration have been Baldwin compounds. It is therefore proper that I should make some remarks in regard to the conclusions or opinions offered by this committee. Preliminary to those remarks, I might say that up to the present time we have some 460 compounds, all told, on order, and we have slightly more than the number here given in service.

The first opinion that the committee offers is that the compound is suitable for a variable class of freight service. I take exception to that opinion in this way: We consider that the compound is suitable for all classes of freight service. We have compound locomotives working in freight service that weigh from the lightest ordinary American type of engine up to the very highest decapods, weighing 200,000 pounds. We have reports from the railroad companies using those locomotives that the light engines give satisfaction in the service that they are employed in, and that the decapods give satisfaction in the service that they are employed in.

Therefore it is very proper to suppose that compound locomotives not only give satisfaction, are not only suitable for a variable class of freight service, but for all classes of freight service.

The second opinion of the committee is that "its range of economy in such service is fully as wide as that of the simple." It would seem to me that that would read better if it said that its range of performance or of coal consumption per ton-mile is fully as wide as that of the simple engine. We have found in all cases where compound engines have been compared with simple engines of the same size in the same service, no matter what that service has been, that the economy has been affected—the economy has varied and increased, as the demand was made upon the engine. In other words, the harder you work the plain engine and the compound alongside of each other, the higher the rate of economy would be for the compound engine.

The third opinion of the committee is: "Its increased coal economy over the simple in the average freight service of the country will be found to lie between 10 and 15 per cent. when in good running condition and handled with intelligence." I wish to state here that I think that 10 and 15 per cent. is the minimum fuel economy that any compound engine of any type, two-cylinder, three-cylinder, or four-cylinder, could probably effect in freight service; that is, in average freight service. I had occasion a short time ago to inquire into the condition and the performance of two compound engines. They had apparently been turned down. They were no good. They wanted no more of them. Upon asking for the figures for these two compound engines to substantiate the statement, it was found that no figures were there, and the master mechanic was told to give the figures. He was a new master mechanic and knew nothing about the engines, and very gladly had the chief clerk hunt the figures up. To my surprise the figures showed that for an eighteen-months' performance of those engines the fuel economy per year on those engines had amounted to $1,680 each; that the mileage for the last month of eighteen months service was the maximum mileage that those engines had performed while on the road; that the total cost of repairs for those engines for the eighteen months had been some 39 per cent. less than the average of all the engines on that division. We think that the average fuel economy in freight service should not fall below 20 and 25 per cent. We have known it to run far beyond that. We have reports from some railroads that show very much larger economy than that, and it is reasonable to suppose that that economy was obtained or it would not be reported. On heavy grades, with heavy engines, we find that the economy has reached as high a figure as 44 9 per cent. This was done on the Western Maryland Railroad.

The fifth point of the committee is: "A well-designed compound should not be more difficult to keep in a serviceable condition than a simple; that is, its regularity of performance should not be less than the simple." This has also been found to be so—and more than so. It has been found by a number of railroads, especially where bad water has to be con-

Mr. SMITH—I would like to ask why this piping always occurs about the middle of the side sheets.

Dr. HUSTON—I suppose that is the hardest service and develops the piping.

Mr. SMITH—I am rather disposed to think that it is in the cooking of the steel more than in the piping.

Dr. HUSTON—I agree with you. If the steel is not properly cooked and brought to a state of rest, as near as you can get it before pouring it, you are going to have trouble.

Mr. O. STEWART—What are we to understand by that word "piping"? I confess I am ignorant as to its meaning.

Dr. HUSTON—Did you ever make a casting that had bubbles of air all through it?

Mr. STEWART—No, sir; I never made one; but I have seen castings with those bubbles all through them.

Dr. HUSTON—Well, as I say, there is a chemical action going on in the steel which develops these little bubbles, and if they do not get out in time the steel forms around them.

Mr. LAUDER—One statement made by Mr. Smith brings out a fact that we should all dwell upon, and that is that he has got, even with his extremely bad water, boilers that have given him from 400,000 to 600,000 miles service, covering a period of nearly twenty years. I think that is a very remarkable fact, that a firebox on the Chicago & Northwestern road, with their extremely bad water, should give a service of twenty years, while he produces before us here samples taken from a furnace that has run less than one year and is absolutely worthless, being cracked from some cause or other. Now to a layman like myself it seems that if twenty years ago the manufacturers of steel in this country could make a plate that would give us twenty years' service, they ought to be doing the same thing to-day. (Applause). In fact, they ought to be giving us better plate, because they ought to be progressing in their business, as we hope we are in ours, and to know more about the manufacture of steel to-day than they did twenty years ago. Possibly some of the fault lies with us. The average purchasing agent wants the steel that he can buy for the lowest price. Manufacturers well understand that, and if they cannot produce a steel to sell as cheap as the other man, on many roads they cannot sell any. Now I do not suppose there is a railroad in this country on which the mechanical man would not consider the question of price of secondary importance and the question of quality of the first importance. But unfortunately on many of these roads the matter is not settled entirely by the mechanical man. It is settled by some one who wants to make a good showing in his particular department, without regard to the machinery department, and if some fellow comes along with a glib story to tell and a lot of scientific tests formulated in a table and offers steel for a quarter of a cent a pound lower than some well-known manufacturer offers it, he gets the trade. What is the consequence of all this? It forces the man who has been making an

honest article, and making it intelligently, to come down to the methods of those who sell the steel cheaper than it can be made. Now I believe that instead of the price of steel for fireboxes of locomotives dropping all the time, it would be largely for the interests of the railroads if it were increased, if the increase meant a better product.

I think the facts produced here in this discussion should be scattered broadcast amongst the railroads of this country, and amongst the general managers and the men who are responsible for the financial results of the operation of our railroads. Just think of it for a moment: a new boiler costing from $1,500 to $2,000 is put into service, and in ten months torn all to pieces at a cost of I don't know how much, because some one has chosen to put in plate that is improper, while the neighboring engine doing precisely the same work has caused no expense to the owners. I tell you these facts have a broad bearing on the future prosperity of our railroads, and in the West especially, where they are cursed with bad water. This question of firebox steel is one of the questions that is probably as serious a one as they have to contend with—by far the most serious, perhaps. In my country almost any of the steels sold would give us good results, because if we take out a furnace in less than twenty years we think there is something radically wrong. I speak warmly about this thing, for my neighbors; I am not troubled myself; but I know the difficulty of operating boilers in the Western country with this extremely bad water, and I tell you the steel manufacturers and the railroads in combination ought to do something to eliminate this terribly destructive effect that the bad water has on the firebox of the locomotive, if it can be done.

Dr. HUSTON—Mr. Lauder has made some reflections on the manufacturer. I would like to make some reflections on the consumer. I admit all he says—that a very low priced article is by no means the cheapest, and we are all forced down entirely too far. We have either got to quit business or come somewhere near the prices that others are offering. But I would say that they are tying us down to a lot of physical tests. We are not allowed any discrimination in the matter at all. I do not think that the physical tests given out at the present day are the best. (Applause).

Mr. SMITH—I am under the impression that all master mechanics and superintendents of motive power will co-operate with steelmakers in the effort to give them a better article, and will not bind them down to any specifications for steel. What we want is a good article, and I think a good many are willing to pay an advanced price, and those steelmakers who are willing to guarantee their steel can get, I think, a large share of the business. I think that first-class steelmakers ought to be able to give a guarantee with their steel if they are allowed a living price for it. Now I would say to you that last year we put in about seventy-five fireboxes on the Chicago & Northwestern road. We have got about 872 engines; and I think that is a very heavy percentage.

Mr. GIBBS—I would like to say one word more about that physical test. Dr. Huston has objected to specifications for physical tests. Now, there

are comparatively few roads in the country that do make any specifications of that kind, and that specification has been made in the first place on the recommendation of the steelmaker, and I have never heard, personally, in conversation with them, or from any published remarks of theirs, that they had anything better to offer, and I doubt whether they will agree any closer on what is the right thing than the railroad companies would agree on what is the right thing. Consequently that leaves us just as much at sea as we were before.

Another thing: if Mr. Lauder's fireboxes last twenty years on his road, it looks to me as if there was some doubt as to whether the same steel that answers the purpose in his case would answer in ours. It is probable that he gets the same steel that we do. What is the matter with our fireboxes, then?

Dr. HUSTON—I think the specifications too low. I favor 50,000 or 75,000 tensile strength.

(Remainder not heard.)

Mr. SMITH—The engines I have referred to have been running alongside of other engines. They have been from one division to another. They have had a share of all the waters we have on the system, and all the coal, and they have stood the test, while others have fallen down alongside of them, and although we do have bad water, it is evident that we have bad steel.

Mr. J. S. MCCRUM—I agree with Mr. Lauder and some of the gentlemen who preceded me, that the question of the price of steel is of secondary consideration, and I would like an expression from some of the steelmakers here as to whether they think they could produce a better material.

Dr. HUSTON—I will now state what I hesitated to state before. Some ten or twelve years ago the Hartford Steam Boiler Insurance Company wrote to me for a standard of steel that was best for stationary boilers. I gave them steel from 55,000 to 60,000 pounds tensile strength and not less than twenty per cent. elongation in eight inches. I asked them not long ago: "Now you have been trying this rule for the last twelve years, and thousands of boilers have been built under that specification; what is the reult?" They replied: "Not a single complaint." That is my answer to your question.

Mr. JACKMAN—I can say, for Hussey, Howe & Company, of Pittsburgh, that twenty years ago we were making fireboxes, but the price has gone down of late years to such a point that we could not make enough out of them to induce us to stay in that line. So for the last few years we have not been making very many fireboxes. If the railroads of this country and the boiler makers would pay what we consider a fair price for that material, the successors of Hussey, Howe & Company would go back into the business. You will notice that we were making a good steel when Mr. Smith bought that material. (Applause.)

Mr. MCCRUM—Would the manufacturers be willing to guarantee their product for any given time—the number of miles run or the number of

years' service, and let them make it entirely as they want it? I would be willing to pay almost any price, up to ten cents a pound if necessary, for firebox steel. On Western roads, where the water is bad, the matter of the price of the material I do not think enters into the question at all.

Mr. L. R. POMEROY—I would like to say, that in the year 1884 we sold nine fireboxes to the Chicago, Milwaukee & St. Paul road under a guarantee of three years' service; that if they failed within the three years we would replace the steel and pay for the labor both ways. We have heard nothing from the company relative to those nine fireboxes, so we suppose that the material is satisfactory. I suppose they would be willing to make that guarantee again.

Mr. WELLMAN—As I understood Mr. Lauder, he asked the steelmakers if they could make any better steel than they are making. I have been making firebox steel some fourteen years. During all that time I have been trying to make the very best article I could possibly make, and to-day I am trying to make the very best thing I can possibly make. The price does not have any influence at all, and I can say that I believe we are making a better steel to-day than has been made in the last eighteen years. When I cannot make the best thing that can be made, when I cannot make the best firebox plate, or what in my opinion is the best firebox plate, then I am ready to quit the business. (Applause.)

Mr. Smith has some fireboxes on his locomotives that are giving 600,000 miles' service. I would suggest if you can get those old fireboxes taken out it would pay the Chicago & Northwestern road, and it would pay this association, to have the most elaborate physical and chemical analysis or any other analysis that you can have made, in any way, shape or manner, of those fireboxes, and find out, if possible, what the reason is—get all the information you can.

Mr. SMITH—I have had the last box taken out now, but have saved that box, and I am willing to give Mr. Wellman, Dr. Huston or any other steelmaker samples of this for any analysis they wish to make. I wrote the Rhode Island people about two months ago asking them if they had any statistics showing what steel they used in those boxes. They said they had no record of it. They said they thought that, at that time, they were using iron; but this is steel. Therefore I cannot get any information from the Rhode Island people. Perhaps some one else can get it. But I have got one of those boxes saved, and I am willing to give any steelmaker all the samples that he wants, so far as they will go, and let them carry out the test for their own satisfaction.

Dr. HUSTON—I wish Mr. Smith would send me a piece by express.

Mr. McCRUM—I would be very much in favor of buying steel under a guarantee. I would like that guarantee to extend, however, to cover the cost of having to replace it in a given time. But a three years' guarantee I would not consider as anything like a reasonable guarantee.

Mr. FORNEY—I have heard this discussion, and, although I do not know anything about the subject, it seems to me, from what has been stated by

gentlemen here, that the reason we do not get good steel at the present time is that railroad companies are not willing to pay enough, and that if railroad companies would only pay a sufficient price, we could get good steel. Now, it would be a very interesting fact, if it could be established here in this meeting, just exactly what price it is necessary to pay in order to get good steel. That would be a sort of test of the quality of the material that I should think might be of value to railroad companies.

Secretary SINCLAIR—The present tribulations are always harder to endure than those which are at a distance. There is a good deal of complaint at present about steel failing, but those who meet with those difficulties would do well to look back fifteen or twenty years, or even further, at the difficulties that were encountered at that time. Firebox sheets are subjected to tremendous hardships in service. It is very difficult to get any kind of material to stand satisfactorily. Everything in the way of metals has been tried for that purpose that could be purchased, and so far steel has been found most satisfactory. There has been of late years so little difficulty with steel that many railroad officers began to conclude that any kind of steel would do very well for firebox purposes. There is no doubt but that there is a great deal of cheap steel being made, and presumably inferior steel. The buyers have been inclined to think that it is good enough, and failure has taken place. It is well to keep up to the high standard, and remember that it has not been inferior steels, but steels of a very superior quality, that have made that material a success for the fireboxes of locomotives. Steel for fireboxes has been like iron for rails and many other things, as it began to get cheap it began to get bad, and I should wish to advise those who are buying steel to see that it is of the very best quality, and that it has the reputation of a good maker behind it, before they take it and put it into fireboxes.

Mr. O. STEWART—I move that the discussion of this question be closed.

The motion was carried.

The PRESIDENT—We will now take up the report of the Committee on Uniform Locomotive Performance Sheets.

This report was read by Mr. JOHN A. HILL, as follows:

UNIFORM LOCOMOTIVE PERFORMANCE.

Your Committee, appointed to investigate the subject of uniform locomotive performance statement, beg to submit the following:

First. We would recommend that all passenger and freight mileage be based on actual miles run, and five (5) per cent. to be added to all freight mileage; that all engines in construction or snow-plow service be allowed at the rate of ten (10) miles per hour; all engines in switching service be allowed at the rate of

eight (8) miles per hour, no percentage to be added to this class of mileage. All other runs of less than one hundred (100) miles freight or passenger, actual miles to be allowed, regardless of what engineers and firemen may be paid for such service. No extra mileage should be allowed going to and from the roundhouse. When an engine is assigned to more than one class of service, the mileage should be computed, so as to show each class of service.

Second. In the distribution of fuel, one (1) cord of wood should be rated as one (1) ton of coal, and all expense in connection with the handling of fuel, either wood or coal, to be included in the cost of same; all coal to be rated at two thousand (2,000) pounds per ton.

Third. In the distribution of illuminating oils, only such oils as are used in the head-lamps and lamps and torches belonging to engines should be shown on the performance sheets.

In the distribution of lubricating oils, we believe all oils used in lubricating engine, including that used in packing driving-boxes, tender and engine trucks, while engine is undergoing general repairs, should be charged to repairs. All lubricating oils used on engine after engine goes into service, to be charged on cost and performance sheets as lubricating oil against engine.

Fourth. In showing the miles run to one pint of oil, the engine, valve and illuminating oil should be separated, showing the miles run to one pint of each, and a separate column be made on engine's statement, giving the total average for all kinds of oil.

All waste used by engineers and firemen, and by wipers for wiping engines, should be shown on performance sheet, and the miles run to one pound of waste given. Waste used on engines while undergoing repair should be charged to repairs.

Fifth. In the apportionment of the expense of labor for repairs of engines, we believe no labor should be charged for repairs other than performed by mechanics, helpers, and those actually working on repairs; laborers, sweepers, sanding and turning table, cleaning round house andother outside work in and about roundhouse, should not be charged to repairs, but should be charged to locomotive service.

All undistributed labor, such as superintendence, clerks, etc., should be prorated over general shop expense. Cost of engine repairs, caused by accident due to other than engine failures, to

dividing the 38 by 17½, we find that if the cylinder repairs were three times as heavy on the compound as on the simple locomotive, they would still barely come up to the saving of fuel, so that there would still be a slight percentage gained.

Of course, this 20½ cents per 100 miles does not look very extravagant. Yet I must say that I have taken this compound at 10 per cent., whereas experiments show an economy in engine and passenger service of 13 to 20 per cent., and some consolidation freight engines we have recently put in service, of the four-cylinder type, have shown an average economy in the neighborhood of 20 per cent. in fuel. The firemen very much prefer to run the compound engines. Taking it 6,000 miles a year as an average mileage, and allowing at the above rate 20½ cents per 100 miles run, we find that the saving would be $123 a year. That, of course, seems like a small amount, but if we take into consideration the extra cost of compounding, which is, I believe, $600 an engine, that would show us still a saving of 20 per cent. interest on this extra investment, paying for the compound.

Mr. John Medway—If there were any doubts in my mind regarding the economy of the compounds, they have been set aside in the last few weeks. With an order for a few mogul freight engines from the Rhode Island Locomotive Works, we decided to include one compound of the two-cylinder type. It was built precisely like the simple engine, excepting the parts due to the compounding. The cylinders of the plain engines were 20 x 24 and those of the compound 21 and 31 x 26, thus making the engines of about equal power. The safety valves were set uniformly at 180 pounds. In order to give the compound a good fair test under everyday conditions, I arranged to put it in competition with the plain engine by having it alternate daily on fast freight trains to Bellows Falls and return. The trains were of substantially the same weight, and other conditions about similar. After ten trips our fuel record showed that the compound had effected a saving over the plain engine of 23.2 per cent., which at $3 per ton means a saving of about $2,000 a year, or, as Mr. Vauclain stated, in five years the cost of the locomotive. The cost of repairs, however, was largely against the compound, which was due to a weakness in the large piston and the dash-pot. These parts have now been strengthened, and if the good fuel conditions can be maintained I can see no reason why the compound is not a good permanent investment. This, however, can be better determined a few years hence.

Mr. G. R. Joughins—Last year we commenced to think about compound engines, and in looking over the question we concluded that we might reasonably expect a saving of 15 per cent. at least in freight service. On that conclusion we ordered from the Baldwin Locomotive Works one freight and one passenger compound. Those engines have been running about eight months now. The freight engine is doing work which had previously been done by some simple engines of exactly the same dimensions, received from the Baldwin people also. We find the results with that freight engine to be very satisfactory. The engineers like the engine. It

seems to have ample cylinder power. The fireman likes the engine because he has not got so much coal shoveling to do. We have not attempted to make any test of these engines. We keep an elaborate performance-sheet, and we determined to rely upon that performance-sheet simply. We find that there has been a uniform saving every month, amounting to at least 20 per cent., in fuel. We do not find that the oil has been required more copiously. It is apparently about the same for freight work, except, of course, the first month or two in which the engine was put in service. The repairs of that engine we find to be practically the same as the ordinary engine ; that is, the running repairs. We cannot see that it is necessary ever to keep that engine from a trip, or that it has any large repairs required.

On the passenger engine, however, we have been rather unfortunate. A great many small matters have gone wrong with that engine, partly, perhaps, due to the higher speed at which it is worked, but I think mostly from rather undeveloped designs and a little bad workmanship. The result of these troubles has been that we are not quite satisfied with the passenger engine. We bought that passenger engine with a definite object. We have sometimes, during the truck season especially, very large trains of perishable freight. I mean large trains compared with the speed at which we had to haul them. We take on twelve or fifteen or even more 60,000-pound freight cars loaded completely and run them at passenger speed. The engine does this very satisfactorily so far as speed and power and general performance are concerned, but, as I said before, it has given us trouble in many little details. I do not know whether to conclude that the compound engine is not suitable for passenger service or not. It is rather a small experience on which to base any conclusion. But I was over in England last winter and, of course, I went to see the Crewe Works, and also went to Gateshead on the Northeastern Railway. At the Crewe Works I was surprised to find that they had not built a single compound engine for eight months, except the engine which was then under construction, and which is now at the Exposition in Chicago. That seemed to indicate that the compound was not quite a success on that road.

I then went to the Northeastern Railway, to Mr. Worsdell's works, who, we all know, has been long a very strong advocate of the compound engine, and I was still more surprised to find that they were building twenty locomotives for passenger service with simple cylinders, and abandoning the compound for that purpose. I did not quite get at the reason why they abandoned the compound for passenger service. It was a little difficult to get an expression of opinion. But in talking to other people on the railway, they said that they found the compound rather unwieldy for passenger service, considering the slight advantages which they derived from it otherwise. The saving in coal was perhaps a little, but there were other things which militated against that and which destroyed the value of the compound on passenger service. I would say in regard to oil on compound engines, that I think any report which the committee has made about the

consumption of oil is utterly valueless. I think we all know that a locomotive very seldom, indeed, receives the oil which is necessary for lubrication. It receives the amount which in the judgment of the engineer he thinks is needed, and that is often two, three, four and five times the amount actually necessary. I therefore think that the oil question is quite undetermined yet, and the figures given are of no service. In determining whether a compound engine ought to be used in passenger service or not, we must, of course, remember that the engines are still in their infancy, and that if we go along experimenting with those engines in freight service that we shall perhaps eventually obtain an engine which is very desirable for passenger service. Notwithstanding the apparent success of those compound engines on the Reading road, and on the Jersey Central, I think that it is still a very undetermined matter about the success of those engines in passenger service.

In obtaining the results from different people of the test of compound with simple engines, we all notice that they vary very much indeed, and a very large factor comes into that question. In determining the relative efficiency of the compound or its relative economy, the question is, What is the efficiency or economy of the simple engine against which it is being tried or tested? The compound may be tested against a simple engine which is a very poor machine indeed, or the simple engine may be a good engine and the compound may be a bad one, or it may be improperly handled. There is, therefore, I think, a very important question to determine, What is the factor of efficiency as a machine of the simple locomotive against which the compound may be tested?

Respecting the way in which a compound engine may be abused, I can give you one very good example. When we received those two engines from the Baldwin Works, I was preparing to go away for some time, and I had only time to receive the engines and see them through a trial trip before I left. On my return, ten or eleven weeks after, of course one of the first questions I asked was what about the compounds, and to look at the figures on the performance-sheet showing the fuel consumption. I was very much astonished to find that the compound passenger engine was using 50 per cent. more fuel than the simple engine. I thought that was not right. In the meantime, while they were doing this, eating up all this coal, of course they had no one to instruct them in the use of the compound.

I took a few rides on the engine and I talked to the engineer a little, and we have now, instead of the compound using more fuel, she uses somewhat less fuel than the simple engine—a little less, say 10 or 12 per cent. This has been all brought about simply by talking to the engineer and showing him that the engine was a compound engine, and that it was not to be used to its full capacity all the time with the live steam running into the low-pressure cylinder. That was his chief fault. The result, I say, of that talk has been a very considerable reduction. I think we reduced the coal per car-mile somewhere about 75 or 80 per cent., and I thought that a very good example of how a compound may be abused.

Mr. David Brown—When the committee wrote to me for information with regard to the compound, I said that I did not have any up to that date. But since then the road on which I am employed has got one. It came about in this way. We have pretty heavy milk trains running, and the milk trains make a rather heavy load for the engine. That is, it was too heavy for the traffic department. We thought the engine ought to pull the trains, but we found that the engine would not pull the number of cars they wanted to put on at that time. Consequently, I began talking the matter up to see if I could not get a couple of engines made to do the work. They wanted them at that time to pull eight cars. They could pull seven, on the hill, but not eight. I had permission to build a couple of engines. We got talking the matter over, and it was finally decided that we would build one of them compound. The idea was that we would build them ourselves. But I said that we would have to have some castings, etc., and it would not pay us to make patterns, and I was told to buy what we could get. The Baldwin Locomotive Works very kindly offered to sell us anything we needed, but they put in—Why not let us build it? I thought it would probably be better for them to build it, and the thing culminated in an order being given to them. It was an engine something similar to the engine on the New Jersey Central.

As soon as that order was given we started to work on another engine. On the 13th of January we received the Baldwin and on the 26th of January our engine was out of the shop, and the two engines being something of the same size it naturally caused a little bit of excitement among the men, and the superintendent put them on some trials to show one against the other, and the first trial that they were put to the cars were increased to twelve with a heavy caboose of 34,000 pounds. They had a helper on the engine. The hill is about seven miles long. The superintendent told the puller to go ahead and let the compound take them alone, and she did take them alone and went up in thirty-six minutes. The schedule time was twenty minutes. The next day the superintendent thought he would try the regular engine that had been on that train. She was a mogul engine 19 x 24. The puller was told to go ahead. She did go ahead, and when a mile out of the city she stalled. The thing went along, and two days after, the simple engine, that we had built, was put on the train. This was a 20 x 20, with boilers the same size as the Baldwin—64-inch. We had more flues—288 flues, and the fireboxes are a little wider. She was put on the train, and took the train up in twenty-eight minutes. That was eight minutes less than the compound.

The next thing, when she returned, they cut the simple engine out at Stroudsburg, and laid her over two or three hours to bring the vestibule train up and see what she would do with that. I will state that, at that time, the regular passenger engine would lose anywhere from four to six minutes in the forty-five minute run up hill, and at the best she would never make the time within a minute. The train of five vestibule cars was a little too much for her to make her regular time in, and they put the

ing of the performance of the engine. It certainly ought to be kept off the performance sheet.

Mr. FORNEY—I have recently had a good deal of experience in making comparisons of the performance sheets of locomotives in this country and in Europe, and in going over the different sheets that have been sent to me, I find it very important, in order to make any sort of fair comparison, that there should be a division of the traffic, that is, that we should know all the expenses of the passenger trains and freight trains and switching trains separately. I do not observe in this tabulation here that such a division is contemplated.

Mr. HILL—It is all classified on page 4.

Mr. FORNEY—But the consumption of fuel and the other expenses are not divided. They go into a general statement in the lower form.

Mr. HILL—Each individual engine would show its service—passenger, or whatever it was.

Mr. FORNEY—Would there be a tabulated form dividing the passenger and freight service?

The PRESIDENT—I take it so.

Mr. FORNEY—I did not think from what was stated here that that was contemplated. Take such a road as the New York & New Haven, which has almost exclusively passenger traffic, it would be impossible to compare that with a road which has almost exclusively freight traffic unless such a division was made. That was a great difficulty I encountered in making comparisons of performance.

The PRESIDENT—It would have given a great deal more information if they had tabulated a regular performance sheet as they propose to have it appear.

Mr. C. F. THOMAS—As I understand that heading, it will make one complete line across the top of the performance sheet, and that when it comes to the first column—the engine number—that would be designated under the mileage of passenger and freight, and a summary of the expense would be run out and put up in columns under passenger or under freight.

Mr. McCRUM—That is the idea.

Mr. HILL—For instance, engine No. 10 was a passenger engine. There would be nothing in the freight column at all. It would show at once that it was a passenger engine.

Mr. FORNEY—Would there be a recapitulation there—summing it all up—showing what is done on passenger service and what is done on freight service?

Mr. HILL—That could be done, but we had to shorten this, because a good many roundhouses are not long enough to put the sheet up. This is about four feet long now.

Mr. FORNEY—In many of the reports which are made, notably on the Pennsylvania Road, they give a recapitulation at the end, collecting together all the passenger service and all the freight service and giving an

average. Now, that is an immense advantage in making the comparison of locomotives on different roads. I should think that would be a very grave omission if that was not included in any proposed publication of statistics. I would move you that the committee be requested to prepare some form of recapitulation of the performance of locomotives to be submitted to the association.

Mr. BRIGGS—I second that.

Mr. HILL—Do not the last two items satisfy Mr. Forney—average number of loaded cars per train? Does he want an average sheet for all of these?

Mr. FORNEY—I want the average number of cars in passenger trains and the average number of cars in freight trains.

Mr. HILL—The next to the last line provides for that, on the corner of the table.

Mr. FORNEY—That says "Average number of loaded cars per train." I am speaking now of a recapitulation in which you sum all up.

Mr. HILL—It is entirely customary now on all roads to sum up the passenger in one line and the freight in the other.

Mr. FORNEY—But I do not think that is provided for in this form.

Mr. McCRUM—It is, with this exception—if the engine had a joint mileage, freight and passenger, it would go in, so many miles freight and so many miles passenger, and it would not be separated.

Mr. FORNEY—I am aware that this form gives the passenger mileage and freight mileage of each engine. But there should be a form in which the performance of all the engines is recapitulated, giving the average consumption of fuel per passenger mile and per freight mile. Such a table as that is of the utmost value in making comparisons. It also should be tabulated, giving the average number of cars in all passenger trains and the average number of cars in all freight trains. If they are separated it is almost impossible to make a comparison.

The PRESIDENT—You would wish a consolidation of all the passenger and freight engines and the average cast on them all.

Mr. FORNEY—An average cast on them all, under the head of switching, freight and passenger.

Mr. LAUDER—There are very few items in this report that I would make any objection to, but it seems to me, as long as we have got this matter now in hand and have a committee appointed, that they should also prepare and give us a form of exchange sheet. Now, these forms that are presented are well enough for certain purposes, but no one would like to have a form like that for an exchange sheet to mail all over the country, because no one cares what the number of the engine is, or what the name of the engineer is. I do not suppose the committee had that in view at all when this was prepared. With the exception of the objection that Mr. Barnett brings up, which I fully sympathize with, I see nothing to criticise, but it seems to me that this whole matter should be referred to the committee, with instructions—definite instructions to report next year, perhaps making some changes here—a form for an exchange performance sheet.

Mr. HILL—A postal card—is that what you want?

Mr. LAUDER—A postal card if thought advisable. Then we can see at a glance, if the accounts are all kept in the same way, just what the other man is doing. I see no reason why the allowance of mileage for switching engines should be increased from six miles to eight. Possibly the increased weight of switching engines used to-day over what they were when six miles an hour was used would justify an increase. But several experiments have been made, to my knowledge, in the last few years, and they never ran very long, because, instead of being six miles an hour, it was two or three, and careful observation has shown me that six miles an hour is a large mileage for the average switching engines as regards fuel. But when it comes to repairs, it is small. I believe that six miles an hour is about right, taking the total cost of running the engine. I think that in any of the published reports where the cost per mile and fuel and miles to the ton of coal are kept in the different classes of service, you will notice that switching engines get sixty to seventy and eighty thousand miles, and I have seen them get 120,000 to the ton of coal at sixty miles an hour—very likely small light switches doing very little work. That being the case, I should be rather inclined to criticise raising that to eight miles an hour. It might make our accounts look a little better to our general officers, but there is one fellow we do not want to deceive—namely, ourselves, and I should favor putting that back to six miles an hour, as it has been for twenty years. I should also be in favor of striking out that clause that Mr. Barnett mentioned. I think that will give us lots of trouble, and I do not think it really amounts to anything. The percentage of cost due to accidents is very small on all well-regulated roads, and we assume they are all well-regulated now. To undertake to make a separate item of that would cost us a great deal of trouble. It never occurred to me before that that should be made a separate item. Now, if my neighbors that I exchange performance sheets with are eliminating that item of cost, I have been behind all these years, and have been using a greater cost on the same basis than my neighbors. It seems to me that the motions now before the house had better be withdrawn and the whole thing remanded to this committee, with instructions to strike that out if it meets the members' views, and also with instructions to bring in a form for an exchange performance sheet with a recapitulation in a condensed form of the whole thing, so that all roads that choose to come into this can see at a glance, when they exchange, whether they are doing as well as their neighbors. I make that suggestion. I will not make any motion, because there is a motion before the house now.

Secretary SINCLAIR—I withdraw my motion with the consent of the seconder.

The PRESIDENT—I think that Mr. Forney's suggestion to make a recapitulation of the performance sheet for the purpose of exchange is a very fair one. I believe it is the only way to handle a performance sheet. But there are conditions connected with that which strike me as being very necessary, and one is a recapitulation of the classifications of engines. If

a railroad, for instance, is running consolidation engines entirely, showing in the recapitulation the cost per car mile, another railroad is running light engines or simple engines, 17 x 24 we will say, and showing the cost per mile, we have not anything in this recapitulation to show what the performance would be of those engines, unless you classify them. Now, in our performance sheet we make a classification of the engines; classifying them A, B, C, D, etc., showing the value of the large engine over the small one, or the other way, if it happens to be so; and it strikes me that, if that was borne in mind, if the committee was continued to give a recapitulation of the different classifications, it would meet Mr. Forney's idea, and it would be of some value to us, I think. It has been suggested to me by one of the members that there should also be a recapitulation showing the alignment of the road, whether it was a hilly road or a level road. That would make rather a cumbersome sheet, it seems to me.

Mr. Forney—I agree with what Mr. Lauder has said, that it would be of the utmost value if there was a division of the engines into classes, such as 4-coupled and 6-coupled and 8-coupled engines, on the performance sheet. I was afraid to suggest that for fear of getting the recapitulation too large. I may as well speak plainly: During the last year I have been engaged in making a comparison of English and American locomotives. I was making my observations under the eye of the most prominent engineering paper in England, and consequently it became me to be very careful about any statements I made. During this period I have been receiving locomotive reports from nearly all the railroads in the country. There are several difficulties I have encountered in doing that. In the first place, a small proportion of the roads divided the service into freight, passenger and switching. In the next place, a considerably smaller proportion give the car mileage. In the third place, only a few of them give the amount of coal consumed per car mile. Of course, if you know the average number of cars in a train and the number of miles run per ton of coal, you have the data from which you can figure up what you want. But if that was stated in a separate column showing the amount consumed per loaded car per mile, it would enable you to compare the service on different engines. If in addition to that the engines were divided, as suggested by the chairman, into four classes of 4-coupled, 6-coupled and 8-coupled, you could study the amount of coal consumed, and it would show the relative economy of these classes of engines and it would be of excellent service in studying the performances of locomotives.

If in printing the word "tons" in any of these performance sheets it was stated to be in tons of 2,000 pounds, it would prevent a great deal of ambiguity. You are never certain in making a comparison whether you are dealing with tons of 2,000 pounds or of 2,240 pounds. It would be so easy to add in brackets, "tons of 2,000 pounds," which would prevent that ambiguity.

I hope very much that it will be found practicable to carry out the suggestion of the chairman, because it would add greatly to the value of these reports.

The PRESIDENT—I think myself, Mr. Forney, that in making this recommendation to the committee we should have what is known as a master mechanic's classification provided for on the bottom of the sheet.

Mr. FORNEY—I should be afraid about going into that. It might be too cumbersome. The simple classification of 4-coupled, 6-coupled and 8-coupled perhaps would meet all the requirements of the present time. If we go into the other matter we might run into complications that I should be afraid of.

Mr. POMEROY—Instead of putting in "tons of 2,000 pounds," wouldn't it be better to say "net tons" and "gross tons"?

Mr. HILL—If you did that you would have people writing to you to ask what it meant.

Mr. FORNEY—I agree with you. I sometimes get confused about net tons and gross tons.

The PRESIDENT—I presume Mr. Forney refers particularly to hard and soft coal. I presume the hard coal is generally charged 2,240 pounds, while with soft coal the net ton is 2,000 pounds.

Mr. LAUDER—I would move that the committee be continued another year and that this matter be referred back to them with instructions to bring in a form of interchange performance sheet in addition to what they have this year reported.

Mr. FORNEY—I would like to make an amendment to that—that they also inquire into the practicability of publishing a profile of the road.

Mr. LAUDER—I will accept the amendment.

The motion was carried.

The convention then adjourned until the following day.

THIRD DAY.

The Convention was called to order at 9.20 A. M.

The President read a telegram from the President and Trustees of the Village of Waukesha, Wis., inviting the Association to hold its next convention at Waukesha; also a telegram from the Fountain Spring House, Waukesha; also a communication from J. C. Barber and J. N. Barr.

The Committee on Standard Bolts and Nuts submitted the following report, which was read by Mr. Pomeroy:

STANDARD BOLTS AND NUTS.

1. Standard size of nuts.
2. Standard size of bolt heads.
3. Standard size of taps for nuts.
4. Standard taper for locomotive fitted bolts.

At the third annual meeting of the Master Mechanics' Association, the Committee recommended the United States standard (Sellers) for bolts, nuts and screw threads; but in receiving the report the Association omitted to adopt the Committee's recommendation, and consequently the matter went over until the fifth annual meeting, at which time the United States standard was formally adopted as the standard for the Association. This being the fact, the duty of your Committee in the premises is a peculiar one, and its scope circumscribed and limited. On this account it was deemed best that the report should be of a more general character, mainly to urge upon all a rigorous observance and emphasis of the standard.

The Association not being on record as to the (*a*) origin and (*b*) claims of the United States standard (Sellers), your Committee deems it not out of place to give a brief synopsis of the system based upon (*a*) an essay read by William Sellers before the Franklin Institute, April 21, 1864; (*b*) the records of the meeting of the Franklin Institute, held December 15, 1864, and (*c*) the re-

port of the Committee of the Master Car Builders' Association, June, 1882, as sufficiently covering the subject. In 1864 the inconvenience and confusion resulting from the diversity in the screw threads used in machine and other construction was brought up for consideration before the Franklin Institute, Philadelphia, and the Committee appointed by the Institute carefully investigated and recommended the system designed by Mr. William Sellers, and the Institute afterward adopted their recommendation. Practically, the three systems from which they were obliged to choose were, first, the ordinary sharp "*V*" thread, shown in Figures 1 and 2. Fig. 1 represents a section of an inch bolt full size, and Fig. 2 a section of the thread enlarged eight times its actual size.

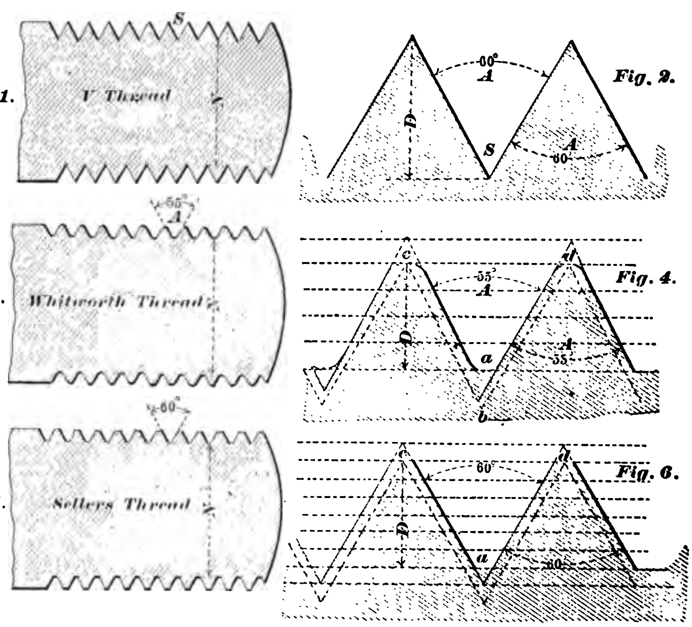


Fig. 1. *Fig. 2.* *Fig. 3.* *Fig. 4.* *Fig. 5.* *Fig. 6.*

Figs. 3 and 4 show Whitworth's thread, and Figs. 5 and 6 Sellers' system. The angle *A* and *A'*, between the sides of the *V* thread is generally 60 degrees, although this is not uniformly so; when it is, the depth *D* from the root of the threads to the

point is slightly less than seven-eighths of the pitch. In the Whitworth thread the depth D is two-thirds of the pitch, and the top and bottom of the threads are then rounded, as shown. The angles AA', of the sides of the threads to each other are 55 degrees. The objections to the V thread are that the point or outer edge of the thread is sharp, and, therefore, very frail and liable to injury from contact with other objects. The space S, or groove, between the threads at the root is also sharp, which facilitates fracture under strain, and is a source of weakness in the screw. The depth D of the V thread being slightly greater than that of the Whitworth thread, the effective diameter N of the screw at the root of the thread is materially less in the former than in the latter.

The objections to the Whitworth thread are that the angle of 55 degrees cannot be measured or laid off with ordinary tools, and that the rounded corners at the point and root of the threads are extremely difficult to produce with any degree of precision in the tools required to make screws.

These considerations led Mr. Sellers to design the system of threads the form of which is shown by Figures 5 and 6. In this the angle of the V thread, 60 degrees, is retained, but instead of rounding the point and root these are made flat, one-eighth of the depth of the thread being taken off at the top and one-eighth at the bottom, which leaves the depth of the thread somewhat less than two-thirds of the pitch. This leaves the effective diameter N of the bolts somewhat greater even than that of the Whitworth thread.

The flat top and bottom in screw-making tools can be easily and accurately made, and the angle of the thread can be produced by simply laying off a triangle having equal sides, or subdividing the circumference of a circle with its own radius, and drawing lines from adjacent points of subdivision to the center. In a report made in 1868 to the Chief of the Bureau of Steam Engineering of the United States Navy by a Board of Engineers, the difference in the resistance to tension and torsion of bolts with Sellers threads, compared with those having V threads, was calculated, and may be approximately stated as follows: That the smaller bolts, with Sellers thread, have about a quarter more strength, the medium-sized ones a sixth more, and the larger ones

an eighth more strength to resist tension than screws having an ordinary *V* thread. Soon after its organization, the Master Mechanics' Association recommended the U. S. standard (Sellers) system of threads for general use in locomotive construction, and in 1871 the Master Car Builders recommended it for cars. Unfortunately, though, when this was done a large proportion of the members of the two associations seemed to have the impression that the U. S. standard (Sellers) system consists simply in a standard for the number of threads to the inch, and apparently not sufficient effort has been made to impress the fact on the minds of those who have the control of such matters that three features are essential to the Sellers system :

1. Screws must have a given number of threads per inch.
2. The threads must be of the form and proportions designed.
3. The diameters of the screws must conform to the sizes specified.

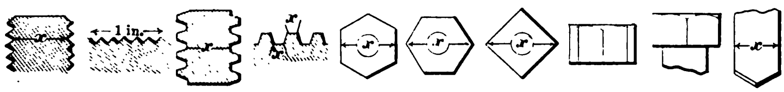
The Committee wishes to impress upon this Association that a specific diameter of screw is an essential feature of the United States (Sellers) system. A screw with a U. S. standard (Sellers) thread must be of one of the diameters given in the table. For example, the outside diameters of U. S. standard (Sellers) screws are 1/4, 5/16 3/8, 7/16 1/2, 9/16 5/8, 3/4, 7/8, 1, 1 1/8, 1 1/4 and upward.

There are no other sizes in the system except some larger than those given, not generally used in car and locomotive construction. There is no such thing, for example, as a Sellers screw 3/4-and-1/32-inch in diameter. That size is not recognized and has no existence in the system, and if a screw is made, as is often done, 3/4-inch in diameter, a sixty-fourth or a thirty-second large, it ceases to be a U. S. standard (Sellers) screw. Uniformity in diameter is as essential to interchangeability as uniformity in the number of threads per inch, or the shape of the threads, and the importance of maintaining the former cannot be too strongly urged on the Association.

The following table gives the results obtained by the use of these formulæ for all sizes of bolts. The only instance where the values in the table differ from those given in the formulæ is in the numbers of threads per inch, which are so far modified as to use the nearest convenient aliquot part of a unit, so as to avoid,

as far as practicable, troublesome complications in the gear of screw-cutting machines.

Standard Screws, Heads and Nuts.



Diameter of Screw.	Threads per inch.	Diameter at root of Thread.	Width of flat.	Short diameter of Hexagon or Square.	Long Diameter Hexagon.	Long Diameter Square.	Thickness Nuts.	Thickness Heads.	Tap Drill.
1/4	20	.185	.0062	1/2	37/64	7/10	1/4	1/4	3/16
5/16	18	.240	.0074	19/32	11/16	[illegible]	5/16	19/64	1/4
3/8	16	.294	.0078	11/16	51/64	63/64	3/8	11/32	5/16
7/16	14	.344	.0089	25/32	9/16	1 7/64	7/16	25/64	23/64
1/2	13	.400	.0096	7/8	1	1 15/64	1/2	7/16	13/32
9/16	12	.454	.0104	31/32	1 1/8	1 23/64	9/16	31/64	15/32
5/8	11	.507	.0113	1 1/16	1 7/32	1 1/2	5/8	17/32	17/32
3/4	10	.620	.0125	1 1/4	1 7/16	1 49/64	3/4	5/8	5/8
7/8	9	.731	.0138	1 7/16	1 21/32	2 1/32	7/8	23/32	3/4
1	8	.837	.0156	1 5/8	1 7/8	2 19/64	1	13/16	27/32
1 1/8	7	.940	.0178	1 13/16	2 3/32	2 9/16	1 1/8	29/32	31/32
1 1/4	7	1.065	.0178	2	2 5/16	2 53/64	1 1/4	1	1 3/32
1 3/8	6	1.160	.0208	2 3/16	2 17/32	3 3/32	1 3/8	1 3/32	1 3/16
1 1/2	6	1.284	.0208	2 3/8	2 3/4	3 23/64	1 1/2	1 3/16	1 9/32
1 5/8	5 1/2	1.389	.0227	2 9/16	2 31/32	3 5/8	1 5/8	1 9/32	1 13/32
1 3/4	5	1.491	.0250	2 3/4	3 3/16	3 57/64	1 3/4	1 3/8	1 1/2
1 7/8	5	1.616	.0250	2 15/16	3 13/32	4 5/32	1 7/8	1 15/32	1 5/8
2	4 1/2	1.712	.0277	3 1/8	3 5/8	4 27/64	2	1 9/16	1 3/4
2 1/4	4 1/2	1.962	.0277	3 1/2	4 1/16	4 61/64	2 1/4	1 3/4	1 31/32
2 1/2	4	2.176	.0312	3 7/8	4 1/2	5 31/64	2 1/2	1 15/16	2 3/16
2 3/4	4	2.426	.0312	4 1/4	4 29/32	6	2 3/4	2 1/8	2 7/16
3	3 1/2	2.629	.0357	4 5/8	5 3/8	6 17/32	3	2 5/16	2 5/8
3 1/4	3 1/2	2.879	.0357	5	5 13/16	7 1/16	3 1/4	2 1/2	2 29/32
3 1/2	3 1/4	3.100	.0384	5 3/8	6 7/64	7 39/64	3 1/2	2 11/16	3 1/32
3 3/4	3	3.317	.0413	5 3/4	6 21/32	8 1/8	3 3/4	2 7/8	3 11/32
4	3	3.567	.0413	6 1/8	7 3/32	8 41/64	4	3 1/16	3 19/32
4 1/4	2 7/8	3.798	.0435	6 1/2	7 9/16	9 3/16	4 1/4	3 1/4	3 13/16
4 1/2	2 3/4	4.028	.0454	6 7/8	7 31/32	9 3/4	4 1/2	3 7/16	4 1/32
4 3/4	2 5/8	4.256	.0476	7 1/4	8 13/32	10 1/4	4 3/4	3 5/8	4 9/32
5	2 1/2	4.480	.0500	7 5/8	8 27/32	10 49/64	5	3 13/16	4 1/2
5 1/4	2 1/2	4.730	.0500	8	9 9/32	11 23/64	5 1/4	4	4 3/4
5 1/2	2 3/8	4.953	.0526	8 3/8	9 23/32	11 7/8	5 1/2	4 3/16	4 31/32
5 3/4	2 3/8	5.203	.0526	8 3/4	10 5/32	12 3/8	5 3/4	4 3/8	5 7/32
6	2 1/4	5.423	.0555	9 1/8	10 19/32	12 15/16	6	4 9/16	5 7/16

Russian Admiralty, so is the French Admiralty. But the Board of Trade go down as low as 20 per cent., so that that elongation shall be, whether 20 or 25 per cent., the elongation taking place within 10 inches of length pulled in an ordinary testing machine. In addition to that the Admiralties fix a standard of tensile strength. They say it shall not be more than 25 tons to the square inch, and they usually say it shall not be less than 24. That is, our gross tons of 2,240 pounds. Now, if you are bound within the range of a ton, you have got to have your chemical composition pretty uniform all through all the plates you make, and if you get an elongation, such as I have mentioned, of 20 to 25 per cent., that is a material that will do very good work.

There is another point that I might mention in practice. We have found by experience that there should be a little difference in the amount of carbon according to the thickness of the plate that you are making. For instance, if you start with .11 for a ¼-inch plate and you are going to make ½-inch plate which shall bear the same 25 tons and not lower than 24, and with the same elongation of 25 or 20 per cent., then you must put a little more carbon into the ½-inch plate than you did into the ¼-inch plate, and so on with the ¾-inch plate, and so on with the inch plate—a little more still. If you keep the same carbon and expect the same tensile strength, you won't get it, because your material is made more dense in rolling down to a ¼ plate than to a ½-inch or ¾. These are features that have led to pretty fair success on our side. I have made many thousands of tons of plate where we have undertaken to be only not more than ten hundred-weight on either side of a given point. In our thickest shell plate, at 27 tons, it would not be more than ten hundred-weight on either side of the 27, and that can only be done by watching the carbon as to the thickness of the plate. We have been very successful indeed by varying the carbon.

I am sure that in this country you have all the raw material that any one else has, in coal and in pig iron and in fire clay. You have all the conditions of purity of material, and if the purchasers and users of the plate were to lay down a standard of purity and strength and elongation, that would be the very first thing to do in order to get that uniformity in your firebox plate which is so much required. Of course, at first your inspectors would have great trouble. They would have to throw out a good many plates. No one has any idea of the want of uniformity in plates who has not acted as an inspector to the firms which are not so closely pinned down. The maker finds that he has got a good lot of material thrown out, and there is nothing like having such a lot of material thrown out to make him find out what is the right thing for him to do.

I am very pleased to have had the opportunity of speaking to you. I want you clearly to understand that I do not say what I have said in any spirit other than as a suggestion drawn from what we have learned in our experience on the other side, especially my own firm. (Applause.)

Mr. John A. Hill—I should like very much to have Mr. Fox tell us the simple way in which he determines the amount of carbon in his steel, which

I saw practiced in his works, and also the way in which he cuts his test-plates.

Mr. Fox—We have what is known as a color-test. Now, a color-test is a known weight of a chemically pure iron, or a known weight of a steel, with a known quantity of carbon. Before the process is started we want to know that we have got the best line of pure iron ore, with such an amount of ferromanganese as we decide upon to mix with it, and get our required quantity of carbon. Unless we know that we have got a pure iron in the furnace, tested by another pure iron, there is no possibility of arriving at the point by mixing a further quantity of ferromanganese with it. To do that, as I said, we have a known small weight of pure iron dissolved in acid and a known weight of water mixed with it. That produces a rather crimson-colored liquid, and more water added to it brings it forward to yellow. Well, we take our supposed pure iron from the furnace and we weigh the same quantity and dissolve it with the same quantity of acid as the other, and then fill up two test-tubes, that are graduated, with such a quantity of water as will bring both the liquids to the same shade of color, looking at it upon a sheet of white paper. The result is that when you read off the difference in the water on the scale of the two tubes, that is the difference in the carbon, less or more, between one and the other. One is considered to be without carbon entirely and the other may have a little in it. But as to getting them both pure, if you cannot get any nearer with your furnace, you then calculate what it has in it at the time and make the difference due to the larger quantity of water in one tube over the other, having filled them both to a point where they are exactly the same shade. That is a very ready method. It can be done in ten minutes. Therefore, your furnace does not suffer any delay while you are carrying the experiment out. Then, again, if you take your pure iron, you want to know what carbon you have in a piece of finished material. Use it in the same way, and read off what the differences are and the quantity of water, to get the two shades the same. In regard to the other point, taking the test-pieces crossway, there is no doubt that you will always get the best result from that way of the plate that has most work put on it, rolling it lengthwise. But we do not quite want that. We want the worst conditions of the plate; that is, to take your test-piece off crosswise. We always adopt that system, and it is a satisfactory one, inasmuch as when you have got your standard of density and elongation on the crossway you are much more sure to be right on the lengthway. (Applause.)

Secretary SINCLAIR—Mr. President, as most of our members are engaged in inland pursuits and are little familiar with what is going on in the marine line, and as some of them may know little of what Mr. Fox has done for the engineering world, if you will permit I would give a few outlines of what I know of Mr. Fox's work, having learned a good deal about it when I was connected with marine service.

When Mr. Fox began his life work on marine boilers, all furnaces were plain cylinders or cylindrical tops—crowns, and the prevailing pressure was

are the amount larger than finished nuts to allow for this finish, but this evidently requires two sizes of *wrenches even for nuts of the same size* bolt-threads. If a bolt is made perfectly straight and fitted into a reamed hole, it is an unsettled question as to how tight it should fit. In practice, the longer and larger the bolt, the nearer it is made to gauge size. A bolt so sized by gauge, as in a short length, to be a running fit, will seem very tight in a deeper hole. The difference between a tight and a loose fit is somewhere in the neighborhood of the ten-thousandth part of an inch. It is held by many locomotive builders that the use of straight bolts is objectionable, on the score that if they are driven in as tight as they say they should be, there is much difficulty in getting them out; that where they are taken out of a hole into which they have been driven two or three times, they become too loose, and there is no means of making them tighter, resulting in their being discarded. What system can we adopt that will enable workmen of limited capacity to do work that shall be commercially accurate? The taper bolt, for certain purposes, presents very decided advantages when considered in this relation." The large majority of bolts used on a locomotive, and made taper, can on the taper of 1-16 of an inch to the foot be driven home, if the size of the bolt and hole is such as will cause the head of the bolt to stand above the top of hole one-eighth of an inch, and when such bolt has been driven home it will have compressed the bolt or stretched the metal into which it has been driven to the amount of 0.0065 inch and the fit will be almost as tight as are car wheels forced on to their axle in the usual manner.

We beg leave to say in regard to the proper taper for taper-fitted bolts, the most practicable, and at the same time the most generally adopted amount of taper per foot, is 1-16 inch; that is, in one foot of length of bolt, measured under the head, the diameter at the end would be 1-16-inch less than that toward the head of the bolt. This taper allows for a tight-driving fit, at the same time permitting a ready removal in case of repairs being necessary, and also makes it entirely practicable to maintain standard uniformity, which, by the use of ordinary straight-fluted reamers, is impossible, by reason of the inevitable wear of the cutting edges of these reamers. The operation of re-grinding, or sharpening reamers, to get the best results, while reducing the diameter,

is obtained by allowing the reamer to enter slightly more, makes up this difference in size, as is evident to any one familiar with the practice of reaming. Thus a one-inch reamer should be one

inch in diameter at its small end. At one foot from its small end it should be 1 1-16 inches in diameter, and if beyond this, if it continues on the same taper, say three inches, it should measure 1 5-64 inches in diameter at its largest end. Such a reamer may be re-ground until its largest diameter has been reduced to the standard size. These reamers are guarded at their upper end by a collar driven on and covering the entire unused part of the reamer, which collar can be from time to time dressed off at the lower end to gauge, to keep the size correct. And this brings up the desirability of gauging in the best way the amount to allow a taper reamer to enter. One of the simplest methods is to use a steel template, or female gauge, hardened steel preferably, the hole of which accurately represents the diameter and taper per foot, the length varying from 2 to 4 inches according to the diameter of the bolt.

The latter, as now generally turned, with a taper attachment to an ordinary lathe, will be a reasonable fit the whole length, if this gauge fits along its length. The small end of the bolt should be turned to allow it to be just flush at this end, the threaded part, of course, outside.

These gauges for any single diameter, and for an average range of lengths, should be a separate template, not having a number of holes in one piece, especially if the template is to be hardened. The taper holes after hardening are to be ground true, so that this condition of distortion is provided for, and the gauges will last indefinitely.

To test the taper reamers an ordinary micrometer and a steel scale will cover the ground, but for more rapid inspection the use of two rather thin hardened taper templates, one to fit upon the small end and the other to be just enough larger to allow it to fit three inches, six inches or twelve inches above it, will quickly decide its true size and taper.

while this is the case nothing more can be done by this association. It is a case where the higher powers would have to take it up and establish some sort of uniformity. Mr. Wilson wanted that explanation to be made and to have his committee discharged.

Mr. Lewis—I move that the committee be discharged.

The President—The next business is No. 6—Standard Diameter of Wheel Centers and Tires. The report is by A. E. Mitchell.

Mr. Mitchell—After the secretary allows Mr. Pomeroy to read the report, I will have something to say on this subject.

Mr. Pomeroy read the following report:

Wheel Centers and Tires.

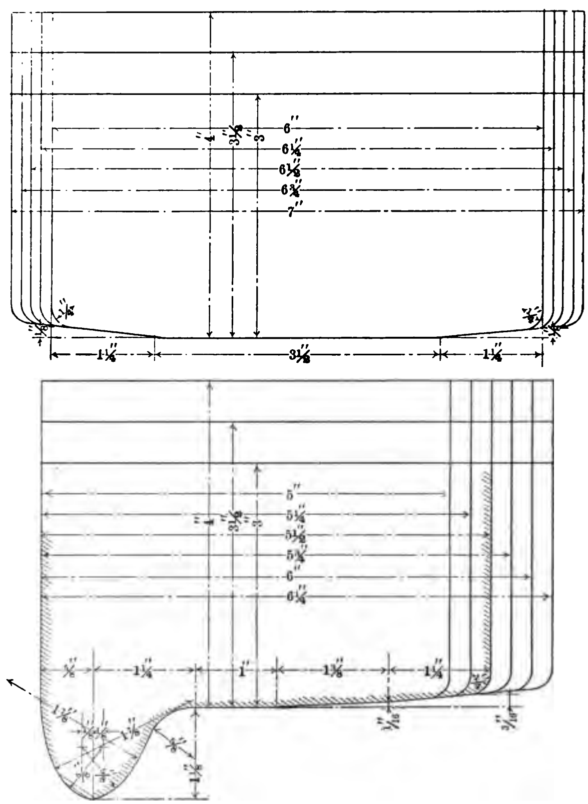
Your Committee appointed to report on diameters of wheel centers for driving-wheels larger than the standard, also to investigate the means of securing uniformity of rolled outlines of standard tires, beg leave to report as follows:

After thoroughly canvassing the subject, we find a majority of the roads recommend that the diameters of the wheel centers larger than our present standards increase by four (4) inches, making the standards above the present, 70, 74, 78, 82, 86 and 90 inches in diameter.

In investigating the subject of uniformity of rolled outlines, nearly all of the roads advised the Committee that they had no suggestions to offer; the subject, however, is a very important one, and should have our careful consideration. We must all agree that if a uniformity in rolled outlines of tires were to become general practice, a large saving would be effected both to the manufacturer and to the consumer. To the manufacturers, on account of their entire output being rolled to one contour, so far as the tread is concerned, thereby requiring the carrying of less stock to supply the demands, the maintenance of fewer sections of rolls, and an incentive to roll the outside so accurately that machining in shops will not be required. To the consumers, on account of being able to order tires for prompt delivery, thereby enabling them to carry much less stock as well as saving interest on the money which otherwise would have to be invested. Each and every Master Mechanic, therefore, should take whatever steps are necessary to lead to the adoption of the Master Mechanics' standard outline of tire on his road, and after it has been adopted, see that every requisition passing through or emanating in his

office specifies the Master Mechanics' outline of tire and that all his gauges for shop use are made exactly to the standard outline.

In our judgment additional widths to the Master Mechanics' standard flange tire and a new standard plain tire of several widths should be adopted, and after careful consideration we



would recommend the outlines shown above for flange and plain tires, the heavy lines representing our present standard.

Respectfully submitted,

A. E. Mitchell,
W. C. Ennis,
Thos. Millen,
C. A. Thompson,
L. R. Pomeroy,
Committee.

In reference to rough nuts and finished nuts, I would say that in my practice I do not use any finished nuts that are movable; they are all stationary nuts, and I do not care so much about a little variation in size. I select the best nuts and case-harden them rough. From the present standard of cold-punched nuts you can select nuts sufficiently accurate. That keeps the case-hardened nut the same as the rough nut, so that it requires the same wrench for both

The PRESIDENT—I think the members will bear in mind one thing that occurs to me, and that is that it is almost an impossibility to get rough iron so that you can use a ¾ nut on it. I think that was the cause of the sizes being added there.

Mr. FORNEY— I have been fighting this battle a good many years, and I hope, if I talk oftener than is good, that the gentlemen will excuse it and attribute it to my zeal in bringing about a reform. The difficulty the chairman speaks of was brought before the Car Builders' Association a number of years ago and discussed at a considerable length, and that association has adopted what are called limit-gauges for round iron. I do not know whether this association has ever adopted that as a standard or not. A member informs me that they have. Well, with the use of these limit-gauges, if the members could only be induced to inspect their iron as it is received and to refuse that which is over or under-size, there will be no difficulty about it. I know that a number of the members of the Master Car Builders' Association found considerable difficulty when the question came up. The manufacturers objected. As a matter of fact, if the manufacturers make iron over-size, they sell a good many more tons for a given order than they do if they sell it under size, and I think that is the secret of iron coming over-size to the extent to which it does. If members would use the limit gauges for iron and inspect every lot which is received, and refuse to receive it unless it comes within those limits, I think the difficulty our chairman speaks of would be entirely overcome. A number of our members told me that after they insisted on having the iron come of proper size there was no difficulty. They could get it.

Mr. DOLBEER—I am a little surprised in regard to these sizes of iron. We never have had any difficulty in the last five years relative to iron being over-size. Many of us remember when we used to get inch-iron and there would be difficulty in cutting a thread on that bolt; but in the last five, and, possibly, I might say, ten years, my experience is that when you buy inch-iron you get it an inch in diameter. I am inclined to think that there are manufacturers of round iron here who will bear me out in this statement. I am surprised at the question coming up in regard to the over-sizes of iron. I have not come in contact with it, perhaps, because we are fortunate in buying from somebody who maintains certain sizes. My experience is that the manufacturers of iron in this country are rolling 1-inch iron 1 inch. I would like to have the experience of other parties using iron to know whether they have encountered that difficulty during the last few years.

Mr. William Swanston—I have been told that on quite a number of contract cars, there are bolts $\frac{1}{16}$ of an inch over-size and that certain tap-makers have been receiving orders for inch-taps and $\frac{7}{8}$-taps—$\frac{1}{16}$ of an inch over-size. To meet this, we understand that the manufacturers have collected quite a large quantity of iron that has been rejected by those that are particular, and they sell it to these car builders at a discount. They get their iron cheap. They get it cheap on account of it being discarded, and they are ordering taps from the manufacturers for the purpose of using up this iron. Now, all of that should be stopped.

Mr. Sprague—I hope that the members will take full interest in this subject. It is a very important one, and if we could only settle it once and stick to our sizes we would eliminate a great deal of difficulty. When I was chairman of the Committee on Shop Tools and Machinery several years ago, I attempted to recommend the purchasing of all standard taps from standard makers, from the fact that it was difficult to make taps in railroad shops, on old machinery, that would duplicate. I wrote to Mr Forney to inquire who the different tap and die manufacturers were. He told me I had better wait a few months. He said they had tried to come together on the subject, and found in the first place they would have to ascertain what the standard inch was. But they have overcome that difficulty largely, and I have found that the taps and dies and nuts of three of the large manufacturers interchange very readily.

Mr. Forney—What Mr. Sprague said is very true. In the beginning of this agitation on the subject of screw threads, Mr. Chanute, who had charge of the machinery department of the Erie Railway gave a large order for cars, and in doing so he was anxious to adopt a standard system of screw threads, and he went to the navy yard in Brooklyn and other places and got the gauges that were used to establish the standard, and he found that no two of the gauges agreed. The Platt & Whitney Company, who have shown a good deal of enterprise in this matter, undertook the manufacture of taps and dies, and the first difficulty they ran against was that they could not find a standard foot or yard on the correctness of which they were satisfied. They finally sent to London and got a copy of the standard yard, which is kept in one of the government offices in London. They got three duplicates of that, and then, at an expense of $25,000 they made a measuring machine with which they could sub-divide that yard with the utmost accuracy. They spent a large amount of money in getting up machinery for making taps and dies with the utmost accuracy. There are also other manufacturers who are making taps and dies correctly. Members need not fear that they will be unable to get taps and dies which are accurate. The difficulty comes in in the rolling mill. The rolling mills find that they sell more iron if they make it over-size. Their rolls wear and they find it more convenient to run along in that way, and unless the people who receive the iron inspect it and insist that it come in the proper size, they will continue this practice. Therefore, I think it would be an excellent plan if this association would have a circular prepared and issued to

all its members and to the managers of the railroads in the country calling attention to this fact. I will make a motion to that effect when this is disposed of.

Mr. SWANSTON—I presume that the thread business is fully understood. But I would like to call attention to the heads of bolts. I heard a great many of the members of this association and others say that they regarded the head of the bolt as too large. There is a disposition to use the turret machine and to use hexagon iron in the manufacture of tapered bolts; tight fitting bolts, and the large head makes the iron very expensive. There are a good many who think that the tapering of the size of the head from an inch bolt to the size of a ⅞ bolt would be amply sufficient. The committee have not recommended this. I only make the statement that such has been the opinion of a great many and that some are doing this. I want the opinion of the association on that subject. I simply call it up for that purpose.

Mr. E. S. MARSHALL, Madison Car Works—Referring to the question of the over-sizes of iron, at the beginning of the present year I went with a contract shop, and on going there I looked over the standards in the sizes. I found that we had specifications from three prominent railroads. The specifications called for United States standards. I also found that it is customary for those railroads to send the samples of the bolts that they require to go into those cars. I was very much surprised to find that all of the samples were over-sized and were not in conformity with the specifications. Therefore, I do not think that you are in the proper line when you condemn the contractors for doing what they are asked to do. In pursuing my inquiry in this line I called the attention of the inspector of one of our very largest systems of railroads to the matter and asked him if they meant what they said in the specification, as our standard was the United States. He said: "We want them patterned after those we sent,' which were $\frac{1}{16}$-inch over-size.

Mr. FORNEY—Mr. President, the motion that is made is that the recommendations of the committee be adopted and that they be amended as I shall read them:

First, That this association commends and emphasizes the United States standard and urges upon all a rigid adherence to the same, and deprecates the use of over or under-sized bolts and nuts, and urges all railroad officers to discontinue the use of screws which are not of standard size.

Second, That it is practicable to maintain the United States standard with the methods and gauges available.

Third, The committee recommends the adoption by the association of the United States standard for nuts based on rough size regardless of finished nuts.

Fourth, That the committee be instructed to prepare a circular calling attention to the importance of maintaining the standards of screw threads, and that the secretary send copies of this circular to all members, general superintendents and general managers and railroad newspapers.

The motion was carried.

The Committee on Boilers for High-Pressure Locomotives submitted the following report, which was read by the secretary:

BOILERS FOR HIGH-PRESSURE LOCOMOTIVES.

Your Committee on "Boilers for High-Pressure Locomotives" concluded, as the number of roads using high-pressure steam on their locomotive boilers was limited, to request the information regarding boilers of this class (the Belpaire included), direct from the (motive power) officers of these roads, in preference to the usual method by circular. The following gentlemen have complied with our request:

Mr. F. W. Dean, mechanical engineer, writes: "The Old Colony compound locomotive carries 195 to 200 pounds of steam and has been running every day since November 4, 1891, making thirteen weeks of continuous service. We do not see any reason to suppose that it is going to be troublesome as to its boiler. There is no evidence that the boiler has a heavy pressure except by the indication of the steam gauge. Personally, I should never think of using any boiler but the "Belpaire" for high (or low) pressure, but few people feel as strongly on this point as I do. I have designed 90 in. stationary Belpaire boilers for 185 pounds of steam, which have given no trouble that I have heard of."

Mr. Wm. Garstang, superintendent of motive power, Chesapeake & Ohio Railway Company, writes: "I wish to call your attention to blue prints of two types of boilers used on this road, carrying a maximum pressure of 165 pounds per square inch. The wagon-top boiler is used in a number of 19 in. x 24 in. cylinder 8-wheel passenger engines, also in quite a number of 19 in. x 24 in. cylinder 10-wheel freight engines. The Belpaire boiler is used in 21 in. x 24 in. cylinder consolidation engines.

"So far as the boilers themselves are concerned, I have not experienced any objectionable features, or increased repairs to same on account of high pressure, but have, however, noticed that the cylinders and steam-pipes work loose more frequently on these engines than on engines carrying 140 pounds pressure and less. Have also noticed that driving-boxes, main and parallel rod-bearings, wear more rapidly. In fact, I believe all working parts

these attachments separately to boiler? Is there any provision made to close the connection between steam-chamber and boiler?

While your Committee have been favored with a sufficient number of replies to give them an idea of the practice in vogue by a greater percentage of the largest railroad systems, still the replies were not as complete as might be expected on a subject of such importance, involving the safety of passengers, as well as employés. Many of the more important questions have been evaded in the replies; others have indefinitely explained their practice, and some have given a very full and complete explanation.

The Committee submit below a tabulated statement, giving in a condensed form the replies received, which, in the estimation of the Committee, represents as nearly as can be the methods and manners in which boiler attachments are applied to boilers by different companies.

RECAPITULATION.

Question No. 1:

E. T. V. & G. report least number of openings.

Average number of openings reported, 11.

Question No. 2:

8 Give no suggestions as to how the number of openings could be reduced.
1 Favors both injectors on one side.
1 Recommends abolishing some of the attachments.
11 Favor use of steam-chamber.
2 Favor use of steam-chamber and water column for gauge-cock.
—
23

Question No. 3:

6 Claim the escape of water and steam could be prevented by use of inside valves.
7 By use of automatic valves.
9 Give no opinion.
1 Claims attachments are too light.
—
23

Question No. 4:

9 No experience with inside checks.
3 Now experimenting.
3 No answer.
3 Experience favorable.
2 Experience unfavorable.
3 No experience, but favor same.
—
23

Question No. 5:

14 Think water-glass necessary.
9 Think water-glass unnecessary.
—
23

7 Think automatic valves necessary to protect water-gauge cock.
9 No answer.
5 Do not consider automatic valves necessary.
2 Prefer shield for protection.
—
23

Question No. 6.

18 Use steam-chamber.
4 Attach parts separately.
1 Uses turrets.
—
23

8 Have no provision to close connection.
4 Use ordinary valves.
5 Use automatic valves.
6 No answer.
—
23

From the foregoing, coupled with their own experience and observation, the Committee have decided on the following recommendations, which, in their opinion, are consistent, and will establish a greater degree of uniformity and safety in boiler attachments.

1st. That all connections for conveying steam from boiler, excepting gauge-cocks, water-gauge glasses, check-valves, blow-off cocks, service cocks, whistle and safety valves, be attached to the steam-chamber, connected to boiler by a flange, to be bolted to the top of boiler, or to the back side of dome, and that a self-closing or automatic valve be used inside of boiler or below a point where the connections with the boiler are liable to be broken, and a valve be placed between chamber and boiler. Illustrations of good practice in this respect are shown in Figs. 1 and 2.

2d. The Committee are of the opinion that a gauge-cock with guard-valve inside of boiler is quite desirable, but not knowing of any form of such cocks, which is entirely satisfactory, refrain from recommending any.

3d. The Committee are of the opinion that water-gauge glasses are not a necessity, while same may be a convenience to engineers

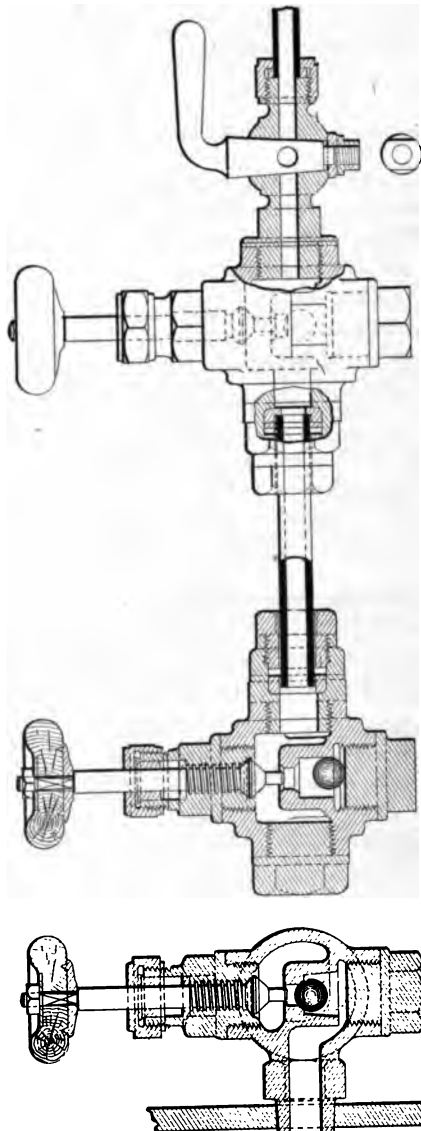


FIG. 3.

Bradley & Poates, Engr's, N.Y.

sixty miles on some of our districts. It is very difficult to tell which is which—foam or water, and it is frequently drawn out of the stacks and the engine is daubed all over—as the boys say, they strike a "flock of birds." In the early days we had an experienced engineer from the Eastern States who took one of our engines, and after running her half-way through the district left her. He said that he had run all kinds of engines, but he had never run a soap-box.

Mr. DAVID CLARK—I would say in respect to this question of water-gauges, that I do not think this association should put itself on record that it is absolutely necessary to have a water-glass on a locomotive. I attended a law-suit recently in Buffalo, growing out of the explosion of an engine, and the killing of the engineer and fireman. The fireman was the support of his sister and she sued the company for $5,000 damages. It was quite a long and tedious trial, but the case was, that there was no water-glass and no fusible plug in the firebox. A number of master mechanics were there from different roads to testify, and it was finally decided that water-glasses were not necessary, and looking at the law of the case, this girl was non-suited. If we put ourselves on record that a water-glass is absolutely necessary, there will be some suits from explosions.

Mr. BLACKALL—I have been connected with the road I am now on for thirty years; we have in the neighborhood of four hundred locomotives, and during all that time we have used no water-glass, and I cannot see the necessity of it.

Mr. SETCHEL—I agree with my friend Mr. Clark in this matter and with Mr. Blackall, who has just sat down, that we ought not to put ourselves on record as saying that it is impossible to run a locomotive without water-glasses. I have run locomotives for a great many years without water-glasses, and there are a great many roads that will not use them at all. But to say that they are not a convenience and an additional safeguard to the engineer, I think is also a mistake. They are a safeguard, and if the engineer will only take care of his water-glass and his gauge-cocks, he will have a double protection against low water. Every locomotive engineer who has run an engine for any length of time will find no difficulty in telling the difference between steam and water, or between his engine foaming and working dry steam. But on a great many locomotives that are being used now, the fireman is removed from the engineer, and for the fireman to have a water-glass is a great help in firing the engine. I do not know but what a good water-glass would enable the fireman, if he pays strict attention to it, to save pretty nearly as much fuel as a compound engine. It certainly is a great aid to a fireman in firing the engine to know where the water is. I think that while we should not say that they are an absolute necessity and that it is impossible to run an engine without them, that we ought to give our sanction to it as an additional precaution to make things as safe as possible.

Secretary SINCLAIR—Mr. President, I have run engines with water-glasses and engines without water-glasses, and I want to testify in favor of

the convenience and safety of the water-glass, and also to combat the idea set forth by the chairman of the committee that it is only tin-cup engineers who need the aid of the water-glass. A water-glass enables an engineer to tell if an engine is foaming in a way that gauge-cocks cannot do. He can also watch the level of the water better than he can with gauge-cocks, and so far as the water-glass getting out of order, every man who is accustomed to it will know by watching the movement of the water if the cocks are getting stopped up. A man who does not know that his water-glass cocks are getting out of order is a very poor engineer. There is no difficulty with the breaking of glasses if they are removed at the right time. A gauge-glass has a life that can be pretty easily ascertained. The steam acts on the lead in the glass and eats it out in a given period, according to the service done by the engine, and it is very easy to find that out and remove it in time to prevent breakage. I am not in favor of the association going on record as favoring the water-glass as an absolute necessity ; but I do not think that the committee ought to have put in an article saying that it is not a necessity, for then those who have anything against it will make sure to use that as a lever against the railroad companies.

Mr. MACBETH—In behalf of the committee, who have given considerable attention and labor to this matter, and also in taking up the remarks of Mr. Clark, I think we ought to try to get these things in a little better shape and not have so much variance of opinion. We worked pretty hard on that, and I do not think that the committee wish to be understood as stating that it is not a necessity. They say—here are fourteen out of twenty-three replies from persons who think them a necessity. Now, there are nine replies from persons who do not think they are a necessity. In taking up the question of this law suit, in which I happened to be subpœnaed, there were some fifteen or twenty of the best mechanical engineers that they could get in the country—a number of them are here now—who were subpœnaed to give expert testimony on this water-glass matter. There was not a man there but said that there was no necessity for the water-glass, and the only instruction the judge gave to the jury was —it has been shown to you here that it is not a necessity to have a water-glass in any shape or form to run an engine ; that they are run with every caution and safety without ; and it was on that ground that the plaintiff was non-suited.

Mr. BEAN—I would like to be fully understood as favoring the water-glass where there is bad water, I believe it is not needed where water is good.

Mr. MITCHELL—I would like to ask if any one is using the check-valves on the back boiler-head and carrying the trough inside the boiler to the front end?

Secretary SINCLAIR—Mr. Foster, I think, can say something on that.

Mr. W. A. FOSTER—My check-valves are not on the back end. They are on the shell of the boiler, about as close up as you can get to a wagon-top boiler. I have got one running that has got a trough about eight feet

long. The check-valve is on the top of the boiler—double-checked. It is working very well, indeed. The trough is about 15 inches wide and 4 inches deep, and extends from the check within about 4 inches of the front flue-sheet. There it is divided so that the water runs off inside. It is clamped on to the dry pipe. My idea was to have the water as hot as possible when it came in contact with the flues. Mr. Boon, I believe, is using check-valves put in the back head on some of his engines, but I do not know anything about the other arrangements inside.

Mr. MITCHELL—Does that pipe confine the water in the steam space? If it does it seems to me it would draw away some of the heat of the steam.

Mr. FOSTER—The trough is in the steam space between the dry pipe and the shell of the boiler. Of course, whatever heat gets into that water comes out of the steam, but the water is so much hotter that it does not prevent the engine from steaming just as well. The only advantage is that you never get any cold water in contact with the flue. Possibly there might be considerable scale deposited in this trough. I think where it is put in on the back end of the boiler it would be a good arrangement to have the pipe go below the water until you pass the firebox a few feet, and then come up and go into the trough.

Mr. CHARLES BLACKWELL—I think that it is the universal practice on the London & Northwestern Railroad of England to put the checks on the back head. I noticed in Chicago, on the engine exhibited by the Canadian Pacific road, that the checks were on the back head.

As regards the necessity or non-necessity of water-glasses, it appears to me the whole matter rests in the locality where the engine is used. In the western or middle section of the country, where water is bad, gauge-glasses are almost a necessity. In the east, where water is good, you can get along first-rate without a glass.

Mr. JOHN MACKENZIE—I have had engines in which the crown-sheet dropped that had glass-gauges, and I have had the crown-sheets drop on engines that did not have glass-gauges. Where the crown-sheet was dropped, with the glass-gauge on the engine, it was on account of the engineer's neglecting to take care of his gauge-cocks, so that when his glass-gauge gave out he did not have any gauge-cocks to work with. If we had some arrangement to compel the engineer to operate the gauge-cocks occasionally, I think the glass-gauge would be a very nice thing on the engine. I think it is a nice thing for the education of the firemen, because a great many of our lazy engineers require the firemen to pump the engine. I do not think that we ought to say that the engine should be run without a glass-gauge, nor do I think that we should say that it should be run with a glass-gauge; but we might say that, as an additional safeguard, the glass-gauge would be a good thing on the engine. The great trouble with glass-gauges, in my opinion, is that they are not fitted properly. Instead of using a five-eighths glass we ought to use a three-quarter glass, and the connection to the boiler should be enlarged so that you absolutely always have a


31½
40½″
50¾″

broken stay-bolts. We all know that broken stay-bolts occur principally in the top rows. The best remedy that I know of is to make the top rows longer. I do not think that in the past the practice has been good in that respect, and I think it is becoming more generally known and appreciated that the longer you get the top bolts the freer you are from the difficulty of breakages. As that becomes better known, I think we will be willing to sacrifice firebox space for the sake of getting longer bolts at the top. You reduce the number of flues slightly, but it is a question whether you do not gain more than you lose. The annoyance of broken stay-bolts is very great, and I think that the true remedy is to get your bolts at the top just as long as possible.

The PRESIDENT—Will Mr. Campbell, of the New York Central, favor us with some remarks upon this subject ?

Mr. JOHN D. CAMPBELL—I have been reading over the report of the committee, and I do not think that there is anything I can say that is not covered in their report and in the letters from the different railroad companies and builders. The remedy proposed of making longer stay-bolts in the upper section of the firebox, I believe, is the true one. It will increase the water space there, giving better circulation down the side, and it will distribute the strain which, with the short stay-bolt, is concentrated at the sheet. I think we all agree that the crown-bar mode of staying the firebox is uncertain. It is uncertain, because we are unable to calculate all the strains on that bar. We have got a personal equation in the construction of the firebox, and that is the boiler maker. It is a bad place to work in. We have got to depend on a man going in there and fitting each one of those pins perfectly. With the radial stays and the Belpaire, we are approaching a point upon which we can figure the strain upon every bolt, every stay that we put in there. Of course, in both types of boiler there is the danger of tapping one thread and cutting another. When we tap it with a long tap—a tap may be 24 inches long, the tap is good in one place. Now, we cut a stay-bolt in another one. The expansion from the heat alone, in the act of cutting that stay-bolt, may make a difference in the thread, so that when we screw it through, with the Belpaire or the radial stay, we have got a different thread. That is one thing in that class of boilers which I think must be guarded against, and about the only thing I see in the radial or Belpaire boilers that we have got to take care of ; while, with the wagon-top and crown-bars, we have got to take care of circulation, and we cannot get it there properly with the small space between the crown-bars and the sheet. For that reason, I fully agree with the report of the committee and the statements made by the builders and others, that the radial or Belpaire boiler is the coming boiler for high pressures.

Mr. CHARLES BLACKWELL—As regards the breaking of stay-bolts, it appears to me that possibly better results may be obtained by using a thread for stay-bolts of a different section to that generally in use. I would like to ask if any of the members have ever used the Whitworth or circular bottomed thread for stay-bolts. It appears to me, from a theoretical point

of view, that stay-bolts of this shape should give a greater number of vibrations before breaking than stay-bolts of the ordinary form, other conditions being equal.

Mr. Pulaski Leeds—I would like to call attention to the proposition I make in this report as to the construction of a boiler of the Belpaire type. It is on page 6. I have boilers built in that way and I consider them about as near perfect as they can be made. I would say that the nuts on top of the roof sheet are made at least 1½ times the thickness of the bolt, so that I can use a fine thread and still get the strength needed.

The President—I would ask if any of the members have observed the practice of turning the thread off between the sheet and stay-bolt.

Mr. Leeds—I am very sorry Mr. Meehan is not here, for he has been practicing that for the last two or three years and claims extraordinary results from it. He turns the bolt to about $\frac{1}{32}$ below the diameter at the thread and almost the entire space between the two sheets.

The President—I think some two or three months ago, in conversation with me, he said he had entirely obviated the broken stay-bolts by that practice. He simply turns out the part bolt between the two sheets, as near as practicable, so that he gets the spring in the center of the bolt instead of near the sheet.

Mr. Swanston—Our practice in the matter is to have a headed bolt, something like an old crown-bar bolt. We turn off between before we cut the thread. We do it in a lathe and use a lathe that has the same pitch, so that we can cut the thread with an ordinary screw machine head on the lathe—cut the point and slip it up and cut the head without the trouble of this expansion, which comes into the bolt by getting a long bolt and making a variation. By that practice we get the exact pitch. We make two taps and fit a solid connection between the two and put it right in and tap it up. Then we take out the connection and take the pieces out and put together again. In that way we get a tap that is exactly correct and we also avoid the trouble from the expansion of the bolt in cutting a long bolt.

Mr. Leeds—In reference to Mr. Meehan's practice, I wish to say that with these stay-bolts on the side of his firebox that he turns out in this way, I have found excellent results in the long radial stays in swedging them down between the screw threads and then cutting them in the usual way. But I have a master tap to which I draw these bolts cold. I find that the variation is so slight that with a top and bottom swedge a few taps of the hammer will lengthen them to come to the master tap. Of course in the stays across the boiler above the crown sheet, they being so long, we can really get a better job in that way than we can in cutting it in the lathe and we are pretty sure that they are right. Of course with the headed crown bolts we cut under the head with the lathe and at the other with the bolt-cutter. I never cut a thread in the lathe that I can cut in the bolt-cutter.

The President—Has Mr. Mitchell, of the New York, Lake Erie & Western, anything to say on this subject?

Mr. A. E. Mitchell—All I have to say is that we are getting very good

Mr. SETCHEL—I would like to ask Mr. Gentry if he has any bad water out on his road?

Mr. GENTRY—On some portions of our system there is water that is a little bad. But on the greater part of our entire road we have water taken from creeks and ponds. We use no spring or well water, and all the impurity is simple silt or mud held in suspension, which is easily washed out. We do not suffer from scale to any extent at all. We can run an engine for several years and take out all the tubes from the holes without having to take out a steam-pipe. We have very pure water. It has not been a question of discipline with our people to make them use what we put on the engine. We have no trouble whatever in making them utilize anything that we put on. We do not think we would have any trouble in making them use the water-gauge.

Mr. JOHN A. HILL—My experience has been entirely in running locomotives. In ten years' service on the Rio Grande road I do not think I ran an engine with a water-glass over three months. Almost the entire equipment had gauge-cocks. On the mountainous section of our road we had good water, but in the southern section of the country we had very bad water. I think that this glass question resolves itself into two things; one is care. Gauge-cocks are in good order because the man uses them every day; he is obliged to use them. You put a water-glass on an engine that uses comparatively bad water, and the man has been used to running with the gauge-cock, and he will not let those gauge-cocks alone, but he will let the water-glass alone. If he had no gauge-cocks and was obliged to take care of his water-glass, I think he would take good care of it. I think that a water-glass is a great help. I think a man would be sure to notice a water-glass where he would sometimes forget to feel his gauge-cock, although just as good results are obtained from one as from the other, so far as I can see. But I believe the gauge-glass is an additional safeguard, and for the little cost I believe they are worth having. But in my experience most of the gauge-glasses are very frail and weak, and give trouble from that cause.

Mr. SPRAGUE—I would like to say one word in regard to the legal aspect of the thing. It has raised in my mind the question whether we are here to give our best judgment as to what is proper and safe for locomotive practice, or whether we are here to evade legal obligations; whether we are here to advance the interests of the locomotive, or whether we are here to whip the devil around the stump and avoid law-suits. I do not think that ought to be taken into consideration. If we are satisfied that a thing is an advantage to the locomotive we ought to advocate it regardless of law-suits.

The PRESIDENT—Do you still desire to press your resolution, Mr. Setchel?

Mr. SETCHEL—I should like to present it.

Mr. Setchel s resolution was adopted by a rising vote.

On motion the discussion was closed.

Discussion on Locomotive Tests.

The President--We will now return to a subject that we have deferred two or three times already, and that is, "Standard Tests for Locomotives." We want to dispose of that, gentlemen, because it was made the special order for this morning. We deferred it until we should have a larger number in attendance. We will now take it up. It is suggested that Mr. Forsyth open this subject.

Mr. William Forsyth--We have occupied more than an hour this morning in talking on water-glasses. I hope you will have patience with me for about fifteen or twenty minutes, or less, in talking about this report on tests of locomotives. The work of the testing department of railroads is growing in amount and importance every year. The proceedings of our railroad clubs and of our association are filled with reports of tests of railroad material and railroad machines. The locomotive is the most important thing which concerns this association, and certainly the tests of locomotives and the report of your Committee on Testing Locomotives are worthy of attention. I will ask you, then, to listen to a short account of what the Committee of Mechanical Engineers and your committee have done on this subject.

In 1890, the Mechanical Engineers' Society appointed a Committee on Standard Method of Testing Locomotives, composed of Mr. Dean, Mr. Cloud, Mr. Vogt, Mr. Stirling, Mr. Denton, Mr. Soule and myself. That committee made a report in 1892, and this report, which was presented to you, is a revision of the report by Mr. Dean and Mr. Lauder. In 1892, Mr. Barnes, Mr. Barrus and Professor Goss were added to the Mechanical Engineers' Committee. Now, the report to the Mechanical Engineers' Society was presented as a preliminary one, and since that, a few weeks ago, it was revised at the Chicago meeting, and Mr. Dean, who was present at that meeting, agreed that his report, which was then in the hands of the secretary of the association, would also need revision, and for that reason, when the report came up on Monday, he was quite willing that it also be presented as a preliminary report. Now, the most important thing which we have added to the Engineers' report is the section on shop tests, of which I would like to read a synopsis :

"Shop tests, as distinguished from road tests, involve the operation of the locomotive to be tested while jacked up, or otherwise arranged to allow the running of its mechanism without a corresponding movement of the locomotive as a whole. Such tests are recommended, and their necessity is urged, because of the facility, when once provision is made for them, with which they may be conducted, the accurate methods of observation which they permit, and the means they furnish for investigating elements in locomotive performance which cannot be satisfactorily developed on the road. Shop tests will not make road tests unnecessary, for it is by the combination of both forms that the fullest information will be obtained ; but it is evident that where such a combination is employed, many of the determinations made in the testing shed will apply to the conditions of the road, and that the road tests may, as a consequence, be much simplified.

importance. We manufacture every year in the neighborhood of a thousand boilers, all the way from an ordinary soup kettle up to boilers 76 inches in diameter. We build about 90 per cent. of those boilers with radial stays or square-stay boilers of the same sort. A crown-bar boiler is the exception. In crown-bar boilers we have to contend with the side stays.

While listening to the conversation here in regard to the methods of putting in stay-bolts, I was surprised to hear that some of the members talked about experimenting with turning stay-bolts down between plates. That has been our ordinary practice. We do it in all cases with the exception of very short bolts located in places where they have never been known to break. I think it would be well to turn down all stay-bolts between centers. It is done just as cheaply as turning a stay-bolt and cutting a thread on it all the way across. If one boy can handle a machine that will cut eight stay-bolts at one time, I do not see why any one should question the expense of doing the work. You can pursue any method you please to make the bolt, but if you do not use the proper material it will be of no use. Take steel that is high in tensile strength—that will stand more vibratory action than steel of low grade. Take pistons made of steel of 55,000 pounds tensile strength and I will guarantee that you will not have one-fourth the life of them as if made of 80,000 pounds tensile strength—provided you have the proper elongation. So it is with stay-bolts. The inclination of a good many people is to get stay-bolts as soft as possible. I do not believe in that at all. What I believe in for stay-bolt iron is an iron as hard as you can get it. You want a good, clean iron of good fiber. But you want it as hard as that iron can be made to allow you to head them up nicely. Iron of that kind will stand a great deal more vibratory action on the boiler than when it is so very soft that you can hammer it up and squeeze it up like putty. We use iron having a tensile strength of 50,000 to 52,000 pounds, with an elongation of 30 to 35 per cent. in a 2-inch section; from 20 to 25 per cent elongation in an 8-inch section. We do not care about a stay-bolt iron that will run below 52,000, and we do not care about 35, 38 or 40 per cent. elongation.

I would like to say a few words on some other matters. In regard to the thickness of plates and the thickness of stay-bolts in high-pressure boilers. I think that the thickness of plate in a high-pressure boiler should depend on the diameter of the boiler and the amount of steam-pressure you wish to carry. Anyone about to construct a boiler should consider what factor of safety he desires, and proportion his sheets accordingly. If he is going to build a boiler 56 inches in diameter he does not want a ½-inch plate. In the diameter of his stay-bolts he should consider the load he will have to carry and he should make it of a diameter to carry that load within a given factor of safety. If this course is pursued I do not believe you will have any trouble with stay-bolts in radial-stay boilers.

Mr. William Smith—I would like to ask Mr. Vauclain whether he increases the size of his stay-bolts in his high-pressure boilers or not, and whether he decreases the space between the bolts?

Mr. VAUCLAIN—We do. We not only increase the size of the stay-bolt iron, but we also decrease the space between the bolts. In a locomotive boiler the thinner you get the firebox plates the longer life you can get out of those plates. The thickness of the outside shell simply depends on the pressure you can carry, but the inside sheets we like to get down to the minimum. For that reason we use a $\frac{5}{16}$ plate for all firebox plate. I do not know but a quarter of an inch would be better, but that would necessitate placing the stay-bolts slightly closer, provided you want to keep the high factor of safety that we adhere to and that is the factor of safety of five.

Mr. SWANSTON—I would like to ask why increase the diameter of the stay-bolts, if there is space for a $\frac{5}{16}$ sheet in proportion to the pressure carried?

Mr. VAUCLAIN—Mr. Swanston puts the question in nearly the same shape, but uses other words. If we reduced the space between the bolts entirely in proportion to the pressure carried we would get those staybolts perhaps too close for service. These stay-bolts would be so close together that the boilers would clog up with mud. As we increase the size of the bolt we simply keep our stay-bolts sufficiently far apart to keep the sheets from bulging. In the other case, with a lower pressure, we can go farther apart and keep the plate from bulging and still carry the strain in these plates with a lighter bolt.

Mr. REUBEN WELLS—I have just come in and I do not know exactly what has been under discussion except that you are talking of the matter of the tensile strength of iron best adapted to stay-bolts, and as I have had no practical experience with stay-bolts for some six or eight years, I am not prepared to discuss that question very intelligently. I think this, however, the diameter of stay-bolts should be proportioned somewhat to the thickness of the sheet through which they pass; that is to say a $\frac{7}{8}$ bolt will break sooner when it is put through a $\frac{1}{2}$-inch sheet than when it is put through a $\frac{3}{8}$-inch sheet, for the reason that the thicker sheet is so stiff that the bolt itself must spring when the expansion of the inside sheet forces it out of its original position; while if it is a large bolt—large in proportion to the thickness of the sheet—the sheet itself will give somewhat in the direction of the strain, and thus relieve the stay-bolt. Another matter tending to increase the life of the stay-bolt is to increase its length. Other things being equal, the longer the bolt the longer will be its life.

Mr. R. C. BLACKALL—Mr. President, we have had no experience with Belpaire boilers, but I must say that our experience with the Wootten firebox and radial stays is not satisfactory. We had several of those crown sheets falling down. I have read in the past year of a large number of boiler explosions throughout the country, and I presume we have representatives of roads here upon which they happen, and I would like to know what class of boilers it was that they had that trouble with.

Mr. VAUCLAIN—Mr. President, we have built, I suppose, more Wootten boilers than any other builders in the United States, and I can safely say that with the Wootten boilers we have built we have had no more trouble

than from any other type of boilers. The Wootten boilers that have exploded and that we have examined into have exploded from the same causes as other makes of boilers. Some explosions have been due to low water, and some to the fact that the boiler has been allowed to go out by the inspector without proper repairs being made to it. The report that a number of boilers had exploded lately has been due to the fact that explosions took place on the Reading Railroad, and to my knowledge only two of the explosions that took place on that road were of Wootten boilers. The others were crown-bar boilers and the remaining one was a radial-stay boiler. The crown-bar boiler broke, I believe, from weakness; the radial-stay from low water; the Wootten from the same cause. We build the Wootten boiler for 200 pounds steam pressure. I have known them to run four years without a broken stay-bolt.

Mr. A. E. MITCHELL—We have about seventy-five Wootten boilers running to-day on the Erie system. Of these boilers we have only had one that has given any trouble, and that was on account of low water. The boilers are giving us excellent service. They are carrying from 150 to 185 pounds. We have no more trouble with them than with other boilers. They are giving us excellent services in every respect.

The discussion was closed on motion of Mr. Sprague.

AIR-BRAKES.

The PRESIDENT—We will now take up the next order of business, which is the report of the Committee on Air-Brake Standards and Inspection and Care of Air-Brakes.

Secretary SINCLAIR—This is a very voluminous report that was submitted last year, and it went over because the Master Car Builders' Association did not agree to it. It is brought up by a joint committee from both associations, and it is very desirable that the action of the two associations should be uniform. Mr. Blackall, the chairman of both committees, has the recommendations that are made by the other association and the changes that were regarded as necessary to make the report satisfactory. I would suggest that he read the changes, or put before the meeting the changes proposed, and what will make the report satisfactory all around.

Mr. BLACKALL read the report, as follows:

SUPPLEMENTARY REPORT OF COMMITTEE ON AIR BRAKE AND SIGNAL INSTRUCTIONS.

We also offer for your consideration the following supplementary recommendations, which were offered and adopted by the M. C. B. Association:

I. Since it has been shown that the packing ring of the piston in the engineer's brake-valve is, in some cases, sufficiently tight

to prevent an accompanying reduction of pressure in the chamber to which the air gauge is attached, when the train-pipe pressure is reduced by leaks, it does not appear to be safe to rely upon the test recommended in the fourth paragraph on page 6 of the report. It is also shown that, in engineer's brake-valves having an excess pressure valve, air from the main reservoir might, under some circumstances, leak past the excess pressure valve sufficiently to compensate for the loss from leaks in the train pipe, if the test were made with the handle in the running position, as has been suggested. Such a compensation is certain to occur with engineer's brake-valves of the most recent construction, in which the excess pressure valve has been replaced by a reducing valve. Such a method for testing for train-pipe leaks is therefore unsafe.

The Committee believes that, while a test for leakage is very important, it would be better to omit it altogether than to require one which may be ineffectual, and we recommend that the fourth paragraph of page 6 be omitted entirely and that the paragraph next following it be amended so that it shall read as follows:

"When the locomotive has been coupled to the train and the brakes have been charged with an air pressure of seventy pounds, the engineman shall, at a signal from the inspector of trainmen, apply the brake and leave them so applied," etc.

An amendment, corresponding to that adopted for this leakage test, will also be necessary in the answer to question 78 of the catechism.

II. We recommend that the sentence in italics, in the fifth paragraph of page 6, be amended by striking out the last two words, "heavy grades," and inserting in their stead the words "such grades as may be designated by special instructions."

This will make the testing of brakes before descending grades subject to the same conditions as those which regulate the use of the pressure retaining valves upon page 12.

The adoption ot this amendment will necessitate a similar change in the first paragraph of page 10 and in the answer to question 53. Question 112 should then also be amended to read as follows:

"How should you proceed to test the air-brakes, before start-

Prof. Goss will be glad to make a run for them if they will make an appointment.

With this explanation, gentlemen, I leave the question in your hands.

Mr. HENDERSON—I think that is a matter of great interest to all of us, and of great importance, and I certainly hope that we will take some action that will look forward to bringing about the result which Mr. Forsyth has explained. There is no question to my mind that locomotive tests are about the most unsatisfactory that we have to make. I have conducted quite a number recently. In one case we had five engines fitted with a certain device, and five engines of the standard type. The trial lasted about one month. Each engine was given three round trips of about 260 miles, so that made altogether thirty round trips, which we took as a basis for future information, and in those different observations we very frequently found that the difference between two runs of one and the same engine was greater than the difference between the total average of the whole series of tests. We were careful to operate these tests in as similar a manner as possible, but, of course, where you have to look out for the regular traffic of a road it is almost impossible to get a satisfactory system of tests. I would like heartily to indorse this idea, and would urge its advancement, and whatever steps we do take I hope will be taken in a very hearty manner, and follow up the suggestion of the American Society of Mechanical Engineers.

Mr. MITCHELL—I think all of us agree that shop tests should be made between simple and compound engines. Therefore, I would make this resolution :

Resolved, That the Committee on Locomotive Tests be instructed to co-operate with the committee from the Mechanical Engineers' Society in a series of shop tests of compound locomotives, to be made on the locomotive-testing apparatus of Purdue University ; second, that the Executive Committee be instructed to provide funds to pay the necessary expenses connected with such shop tests, and solicit subscriptions for this account from railroad companies and locomotive builders, the amount not to exceed $5,000.

Mr. D. L. BARNES—In order to prevent any misunderstanding as to the scope of these shop tests, I would like to describe what I saw at Purdue University and as a member of the committee. The locomotive is mounted on a pair of carrier wheels exactly like a pair of locomotive drivers. It is provided with the same force, makes the same noise and acts exactly as a locomotive does on a road, excepting such things as pertain to the road-bed. I have never been an enthusiast for shop tests, believing that there are many things that cannot be settled in a shop, but there are a great many other things that cannot be settled on the road. For instance, no one knows how to set the valve for a compound locomotive, so far as I know, to get the best results. No one knows how large to make the receiver, or the proper ratio between the cylinders of high and low pressure. The two-cylinder compound locomotives are giving lots of trouble for the lack of that knowledge, and four-cylinder locomotives are giving a lot of trouble

because the valves are not properly arranged. We have not yet seen, as I said the other day, an indicator-card from a compound locomotive at sixty miles an hour that is a credit to the engine or that is as good as a card taken from a simple engine at the same speed. It has been asked whether it is economical to run a locomotive with the throttle partly closed or wide open. That question was settled by the Purdue University tests last year. They tried that test, wire-drawing from 180 to 140 pounds. As had been predicted before, the wire-drawing produced superheating. The superheating was as much as twenty-five degrees, but the economy fell off immediately. The loss of potential, or the loss of possibility of doing work by losing pressure due to wire-drawing, makes a loss of 20 per cent. in the efficiency of the engine. In every case where the dry pipe pressure was 60 to 80 pounds less than that in the boiler, the loss was from 15 to 25 per cent. Such a question as that is very much better settled in the laboratory.

Then, again, in regard to counterbalancing. We have never known, so far as I am aware, just what to do. This Schenectady engine was built with great care. They are known to make very well counterbalanced engines. But she would not run in the laboratory. At fifty-five miles an hour she got dangerous to the apparatus. When the engine went one way the counterbalance went the other. With the pointer on the engine you could see right away what the trouble was. They put on more counterbalance and the engine worked very satisfactorily.

The temperature of the smoke-box is another thing we want to know more about. The pyrometers we have used are wholly unsatisfactory. They vary as much as 200 degrees when put in the same smoke-box and under the same conditions. At the University they use a copper ball which they put in next to the flues. They know the weight of the copper ball. They drop it in water when it comes out, and in that way they get a record of the temperature.

Another interesting thing they found down there was the lifting of the drivers due to the counterbalance. I got down under the machine—it is very accessible—and I could see in between the drivers and the carrier-wheel when the counterbalance was up. But, to settle that question, they fed a wire around between the two wheels and first found that the wire was flattened down when the counterbalance was down. When the counterbalance was up the wire passed through whole, showing that the driver does not lift from the rail. These are only a few questions that can be settled in the laboratory that cannot be settled on the road. This is a very expensive piece of apparatus. No one railroad company would feel justified—unless it was very wealthy—in building it. It is only by the joint action of railroads and locomotive builders that these tests, which are very necessary, can be carried out.

Mr. Gillis—I indorse most heartily Mr. Mitchell's resolution, but I would like to have one change, and that is that this test be comparative with simple engines.

Mr. Mitchell—I should have mentioned simple engines in the resolution. That was an omission.

sary to release the brakes and apply them again later, perhaps repeating the operation. *Apply the brakes lightly at a sufficient distance from the stopping point, and increase the braking force gradually, as is found necessary, so as to make the stop with one application, or at the most two applications of the brakes.*

With freight trains which are only partially equipped with the air-brake, great care must be used to apply the brakes with only from six to eight pounds reduction, and to allow the slack of the train to be taken up before further application is made, in order to prevent shocks, which otherwise may be serious.

In making a service stop with a passenger train, *always release the brakes a short distance before coming to a dead stop*, except on heavy grades, to prevent shocks at the instant of stopping. Even on moderate grades, it is best to do this, and then, after release, to apply the brakes lightly, to prevent the train starting, so that when ready to start, the release will take place quickly. This does not apply to freight trains, upon which the brakes must not be released until the train has stopped.

EMERGENCY APPLICATIONS.—The emergency application of brakes must not be used, except in actual emergencies.

BRAKES APPLIED FROM AN UNKNOWN CAUSE.—If it is found that the train is dragging at any time without a rapid fall of the black pointer, move the handle of the engineer's valve into the full release position for a few seconds, and then return it to the running position.

If, however, the brakes go on suddenly, with a fall of the black pointer, it is evidence that (*a*) a conductor's valve has been opened, (*b*) a hose has burst or other serious leak has occurred, or (*c*) the train has parted.

In such an event, place the handle immediately in position 3, to prevent the escape of air from the main reservoir, and leave it there until the train has stopped, the brake apparatus has been examined and a signal to release is given.

BRAKING BY HAND.—*Never use the air-brake* when it is known that the trainmen are operating the brake of the air-brake cars by hand, as there is danger of injury to the trainmen by so doing.

CUTTING OUT BRAKES.—*The driver and tender brakes must always be used automatically at every application of the train brakes*, unless defective—except upon such grades as shall be designated by special instructions.

When necessary to cut out either driver or tender-brake, on account of defects, it shall be done by turning the handle of the four-way cock in the triple-valve down to a position midway between a horizontal and a vertical position, and leaving the bleed-cock open.

DOUBLE HEADERS.—When two or more engines are coupled in the same train the brakes must be connected through to and operated from the head engine. For this purpose a cock is placed in the train-pipe just below the

engineer's valve. The engineer of each engine, except the head one, must close this cock and place the handle of the engineer's valve in position 2. He will start his air-pump and let it run as though he were going to use

THE ENGINEER'S BRAKE AND EQUALIZING VALVE AND DUPLEX AIR-GAUGE.

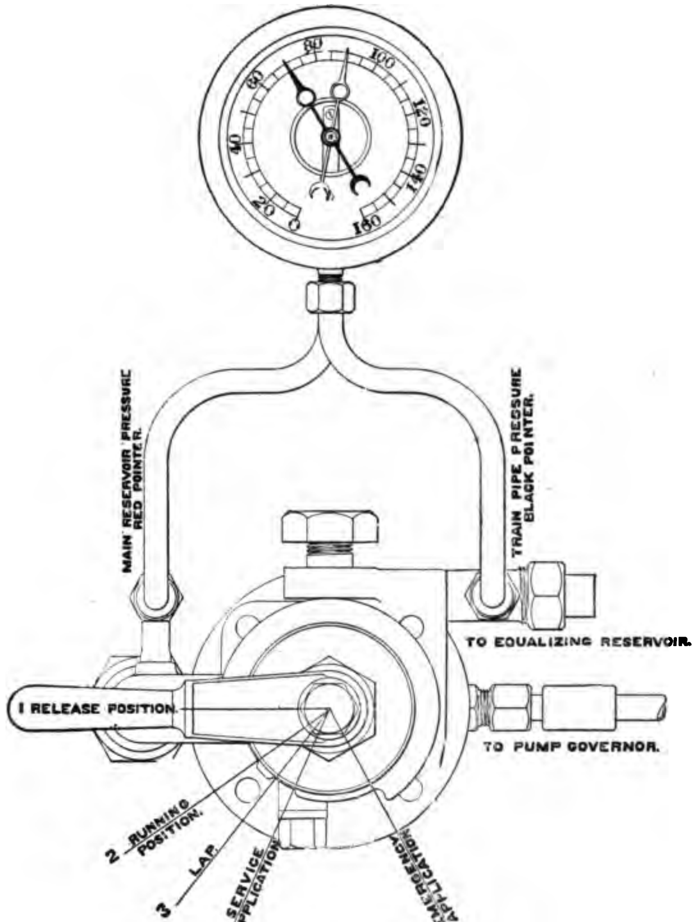


FIG. 1.

the brake for the purpose of maintaining air pressure on his engine and enabling him to assume charge of the train-brakes should occasion require it.

AN EXTRA AIR-BRAKE HOSE AND COUPLING must always be carried on

that there is no evidence to indicate the probability that malleable iron castings can be generally used as a substitute for expensive forgings. Malleable iron castings, as now used in connection with locomotive construction, are principally either substitutes for gray iron castings or for small and inexpensive forgings. The Committee have not reached a single suggestion that malleable iron can be economically introduced in place of the larger and more expensive forgings which are now used in locomotive construction.

In collecting information on the subject, the Committee have, however, been put in possession of a quite complete list of those detail parts of locomotives which are now commonly or occasionally made in malleable iron, and for the information of members and as an addition to the records of the association, we give herewith a list of such detail parts as are, or may be, made in malleable iron :

BOILER FITTINGS.

Stay-bolt cap nuts, water grate-bar bushings, frame pads, crown-bar washers, spark-hopper fittings, fire-door fittings, gauge-cock drip funnels, handhole bridge, gauge-cock stand, gauge-cock wheel, injector handles, injector drip funnel, smokebox door clamps, smokebox hinges, jacket-band lugs, sandbox nozzles, sand-lever handles, grate-lever latch, grate-lever joint pins, ash-pan damper details, bell clapper, bell-shaft arm, whistle lever, whistle-lever crank, whistle-bowl top, cock handles.

RUNNING GEAR.

Reverse-lever latch handle, throttle-lever latch handle, throttle-lever quadrant, throttle-lever latch, link hanger, balanced-valve strips, driving-boxes, eccentric straps, valve-stem clamps, spring clips, spring saddles, pedestal caps.

CAB FIXTURES.

Door fasteners, arm-rest brackets, ventilator brackets, cab handles, cab hand-rails, corner brackets.

BRAKE GEAR.

Bracket for engineer's valve, dummy coupling, hose clamps, hose connections, brake-shaft bracket, brake-heads, brake-shoe adjuster, brake-lever fulcrum, brake-lever guide, brake-wheel.

MISCELLANEOUS.

Flag-holder sockets, lamp sockets, lamp brackets, feed-hose

couplings, feed-hose clamps, feed connection, bell cranks, goose necks, apron hinges, chafing casting-socket, guide-yoke guard, cylinder-cock rigging, front draw-bar rest, pilot steps, front draw-head, truck center-plates, oil cups.

TENDER DETAILS.

Truss-rod seat, side bearings, buffers, truck column, truck-column guide, washers, center plates, truck pedestal, box lid, hand-rail, spring cap, poling socket, journal-box wedge.

R. H. SOULE,
WM. GARSTANG,
W. H. THOMAS,
C. H. CORY,
W. D. CROSMAN,
Committee.

MR. LEWIS—I move that the report be received.

The motion was carried.

DISCUSSION ON MALLEABLE IRON CASTINGS.

The PRESIDENT—The question is now before you for discussion.

Mr. HIGGINS—I would like very much to hear from any of the members who have had any experience with malleable iron for driving-boxes.

Mr. MITCHELL—I understand from conversation with some of the committee that that is one of the subjects they are going to take up next year, and at that time they will have a very full discussion on it.

The PRESIDENT—I would like to ask the chairman of the Committee on Subjects to take that subject up next year.

Mr. MACKENZIE—I move that the discussion be closed.

The PRESIDENT—Before putting that motion I would ask if any member has any experience with malleable iron driving-boxes?

There was no response to the president's question, and the motion to close the discussion was put and carried.

The PRESIDENT—We will proceed to the next order of business, "Attachments between Engine and Tender."

The report on this subject was read by Mr. J. Davis Barnett, as follows:

ATTACHMENTS BETWEEN ENGINE AND TENDER, FOOT-STEPS AND HAND-RAILS.

The tenor of the replies to your Committee's circular clearly show that our members think the risk to enginemen is small from tender either mounting or running under engine foot-plate, in fact is "nil" if the chafing-plates and their backing are in

line and the coupling-bar is horizontal, lying close up to casting. In locating the coupling-bar even better practice is to put it in the vertical center of the chafing-plates, so that the bar has to suffer a straight shear before tender can start to mount engine foot-plate.

Therefore, in the matter of coupling, we indorse the correctness and safety of the practice common in America of coupling engine and tender together, provided the chafing-plates have liberal surface, are of equal height, have ample straight backing (if possible in a single casting), and a stout horizontal wrought-iron draw-bar with cottered coupling-pins of large diameter is used. There are a few who believe that there is more risk to men in case of an accident from the tank moving forward on tender-frame, but no suggestions are made to improve the present mode of securing tank, viz.: by using stout lugs well riveted to tank having the lower flange bolted to frame, and solidly securing the floor inside coal space to frame, so that to shift position the tank has either to mount the floor, or, bodily shear the floor off the frame.

Safety couplings should be used to supplement the coupling-bar, and with two exceptions the replies favor stout chain in short links as better than side coupling-bars. If solid side-bars are used one end should have an oval or slotted hole, so that there shall be no tendency to bind when on curves.

The securing of the ends of the safety chains is in many cases of a most flimsy character. The best sent us is from D. S. S. & A. R., both chains being permanently held to the tender beam by double-ended staple bolts of 1½-inch round iron, the loose ends being coupled to the underside of engine draw-casting by two pair of pendent lugs cast on, through which (and through last link of chain) passes a 1¼-inch horizontal cottered bolt. Many replies say 1-inch round iron is strong enough for safety chains, but the D. S. S. & A. R. very properly use four links 6 inches long of 1½-inch round iron.

Chafing-plates are commonly of chilled cast-iron, 30-inch to 40-inch area, although some face with steel plate, and one takes the wear direct on the wrought-iron wedge. No information is given as to relative cost and wear of soft and chilled iron for this service.

There is apparently no uniformity in the shape of chafing

surfaces, some making both surfaces flat, others make one flat and one round, and the P. & R. use both rounded, each to a radius struck from the center of its coupling-pin. This insures contact when the vehicles are either on curve or tangent without that pinching and bending which is responsible for some of the undesirable lengthening of the coupling-bar.

Half of the members replying use a wedge to take up the slack in bar and the wear in chafing-plates, and it is to be inferred from the limited information given that they use a horizontal wedge, requiring for adjustment the labor of separating the engine from the tender and then coupling up again, as no reply gives any experience with patented or other vertical wedges that take up the slack automatically, that is, take it up by gravity. One reports using an eccentric bush on coupling-pin, to vary the length of coupling-bar.

With the single exception before mentioned the wedge is behind one of the chafing-plates, so that no direct wear comes upon the wedge itself.

Apart from use of wedge and eccentric, no other form of taking up wear and slack is mentioned, other than the old-fashioned practice of taking out the coupling-bar and getting it upset by a smith.

No difficulty or increased resistance in backing around a sharp curve has been noticed with any width or shape of chafing surface, if the gangway or platform of tender is properly curved so that it does not foul engine when on sharp curve.

It is so difficult to believe that some such resistance does not exist, that we were at first inclined to indorse the P. & R. plan of rounding both chafing surfaces to curves struck from center of draw-pins, as this results in the coupling-pins being exactly the same distance apart, independent of the relative positions of engine and tender; but one member of this Committee, with special experience in propelling trains tender first around curves, says, if the chafing surfaces are rounded to any short radius the pressure tends to derail the tender or turn the rail over, and always causes excessive wear on the journal collars of the tender axles. He now uses a flat plate on engine, 8 x 20 inches long, and this length is used to prevent tender chafing-face slipping by the ends and locking, as did occur when a shorter flat plate was used. The

tender surface is 8 x 10 inches long, curved to a radius struck from center of forward tender truck. If other conditions made it advisable to curve the engine chafing surface, he would do it to a radius struck from center of rear driving axle.

The L. & N. W. Ry. and the P. R. R. use a spring buffer coupling arrangement on new work, and the N. & W. R. think such a plan has advantages. The main draw-bar like the side couplings has clearance at one end to allow for free play of spring in compression, as well as freedom in curving.

A fair inference from practice permitting so elastic and flexible a connection is, that its users and indorsers do not consider there is any risk to men on foot-plate that justifies a closer interlocking arrangement.

Probably the intention in using a buffer coupling now—as in the early days of the locomotive—is to increase the comfort of the passengers, as well as to lessen sudden shocks on metal, and the strains tending to rack tender frame.

STEPS.

A full third of the replies express a preference for short steps—that is, under 12 inches long; two specify 12 inches, and the remainder run from 16 inches to 24 inches, emphasis in many cases being laid on the necessity for high flanges on three sides, although some few do not use flanges.

As to position horizontally: some say a low step is safe, but the distance of the lowest step above rail varies from one each of 12, 14 and 15 inches, up to the more common height of 20 inches (that is 24 inches above tie level), and there is an evident reluctance to having more than one additional step above the first step, however close to rail the first step be located, or whatever be the height of the other "risers."

It is not evident why the first "riser" (that is, the distance from tie to first step) should so commonly be higher than the second and third "risers," except it be to clear snow or other obstruction at low level. Even any equal division of the total height by two steps into three equal "risers" is not shown on any reply, although that would appear to be a more judicious and safer course for the men than the common practice.

Two advocate adjustable steps (apparently to be altered to suit the personal ideas of each runner). This the Committee

thinks a mistake, believing a permanent fastening at a uniform height on all engines will, all things considered, offer less risk the year round.

But two advocate steps at same level on both engine and tender, although there seems an additional element of safety in such a course. Apparently there is an endeavor to put all the steps on one of the vehicles (either engine or tender) when this is possible.

The majority say that in material for steps, wood and rubber have no appreciable advantages over iron ; but few use wood, and one only mentions rubber. Roughened and perforated iron plate is the best practice, for although castings with serrated surface are common, the lighter weight and the freedom with which wrought-iron can in winter be struck with a hammer (thus at once disengaging all ice) gives it the preference. The roughening of surface is usually done with a diamond-pointed chisel by hand.

HAND-RAILS.

A strong preference is expressed for long vertical handles on tender-tanks, with an occasional vote for short handles on cab, although it seems as if every reason given for the use of long handles on tanks will apply with equal force to reasonably long handles on cabs—say within a limit of 24 inches. Long horizontal side handles on tank (to correspond with long side steps) are neither used nor desired.

Opinion as to the use of cross hand-rails (that, is hand-rails at front and back) where engine is equipped with pilot, is very diverse. The nearest approach to a generalization of the answers, is that the engines with pilots should not have hand-rails, except for pushing and suburban, and perhaps for some regular way-freight services, because, however useful to railway servants, they are a temptation inviting other people to steal rides at points where they risk life and limb.

J. DAVIS BARNETT,
G. W. STEVENS,
C. E. SMART,
J. W. HILL, } *Committee.*

DISCUSSION ON ATTACHMENTS BETWEEN ENGINE AND TENDER.

MR. J. DAVIS BARNETT—I wish to make one or two points of comment on the report itself and perhaps a point of explanation. Perhaps the point

cars, with the air-brakes in good condition, which may be used in operating the train as an air-brake train.

MAKING UP TRAINS AND TESTING BRAKES.—In making up trains, the couplings must be united and the cocks at the ends of the cars all opened, except at the rear end of the last car, where the cocks must be closed and the couplings properly hung up to the dummy couplings. After the train is charged, the engineer must be signaled to apply the brakes. When the brakes have been applied, they must be examined upon each car to see that they are properly applied. This having been ascertained, the inspector must signal the engineer to release the brakes, using the train air-signal from the rear car, upon passenger trains. He must then again examine the brakes upon each car to note that each is released. If any defect is discovered, it must be corrected and the testing of the brakes repeated, until they are found to work properly upon each car. The inspector must then inform both the engineer and conductor that the brakes are all right.

CLEANSING CYLINDERS AND TRIPLE VALVES.—The brake cylinders and triple valves must be kept clean and free from gum. They must be examined for this purpose as often as once in six months upon passenger cars, and once in twelve months upon freight cars. The cylinders must be oiled once every three months, by removing the plug from the hole in the cylinder-head for this purpose, and inserting about one-twelfth of a pint of mineral oil, and the dates of last cleaning and oiling marked with chalk upon the cylinder in the places left for such dates opposite the words, which will be stenciled with white paint, in one-inch letters, upon the cylinder, as follows:

CYL. OILED ____________________

CYL. }
TRIPLE } CLEANED ________________

The triple valves and auxiliary reservoirs must be frequently drained, especially in cold weather, by removing the plug in the bottom of the triple valve and opening the small cock in the reservoir.

ADJUSTMENT OF BRAKES.—The slack of the brake-shoes must be taken up by means of the dead truck-levers.

In taking up such slack, it must be first ascertained that the hand-brakes are off, and the slack is all taken out of the upper connections, so that the live truck-levers do not go back within $1\frac{1}{2}$ inches of the truck timber or other stop, when the piston of the brake-cylinder is fully back at the release position. When, under a full application, the brake-piston travel is found to exceed eight inches upon a passenger car, or nine inches upon a freight car, the brake-shoe slack must be taken up and the adjustment so made that the piston shall travel not less than five inches nor more than six inches.

BRAKING POWER.—Where the cylinder-lever has more than one hole at the outer end the different holes are for use upon cars of different weights.

It must be carefully ascertained that the rods are connected to the proper holes, so that the correct braking power shall be exerted upon each car.

Repair Parts.—Inspectors must keep constantly on hand for repairs a supply of all parts of the brake and signal equipment that are liable to get out of order.

Hanging up Hose.—Inspectors must see that, when cars are being switched or standing in the yard, the hose is coupled between the cars or properly secured in the dummy coupling.

Responsibility of Inspectors.—Inspectors will be held strictly responsible for the good condition of all the brake and signal apparatus upon cars placed in trains at their stations; they will also make any examination of brake apparatus or repairs to the same, which they may be called upon to do by trainmen.

GENERAL QUESTIONS REGARDING THE USE OF THE AIR-BRAKE AND TRAIN SIGNAL.

GENERAL QUESTIONS.

(All parties who have to do with the use, adjustment, care or repairs of air-brakes should be thoroughly examined on these questions, in addition to the special questions for each class of men following them.

1. Question. What is an air-brake?

Answer. It is a brake applied by compressed air.

2. Q. How is the air compressed?

A. By an air-pump on the locomotive.

3. Q. How does the compressed air apply the brakes?

A. It is admitted into a brake-cylinder on each car, and it pushes out a piston in that cylinder which pulls the brake on.

4. Q. How does the piston get back when the brakes are released?

A. There is a spring around the piston-rod which is compressed when the brakes are applied, and when the air is allowed to escape to release the brakes, this spring reacts and pushes the piston in again.

5. Q. What was the first and simplest form of air-brake?

A. The straight air-brake.

6. Q. How was the straight air-brake applied and released?

A. The engineer applied the brake by admitting air from the reservoir on the locomotive through a train-pipe to all the brake-cylinders, and he released the brakes by first shutting off the reservoir from the train-pipe, and then opening the train-pipe and all the brake-cylinders to the atmosphere, so that the compressed air could escape again.

7. Q. Is the use of the straight air-brake now allowable?

A. No.

8. Q. Why not?

A. Because it has been replaced by an improved form of brake, called the automatic brake.

9. Q. Why is it called an automatic brake?

A. Because it is applied automatically by any derangement which reduces the air pressure in the train-pipe, such as by the bursting of a hose or the parting of a train.

10. Q. What necessary parts has the automatic brake on a car which the straight air-brake has not?

A. One auxiliary reservoir and one triple valve.

11. Q. Where is the compressed air kept ready for use in the automatic air-brake?

A. In the main reservoir on the locomotive, in the smaller or auxiliary reservoir on each car, and in the train-pipe.

12. Q. Where does the compressed air come from directly, that enters the brake cylinder when the automatic brake is applied?

A. It comes from the auxiliary reservoir on each car.

13. Q. How does it get into the auxiliary reservoir?

A. It is furnished from the main reservoir on the locomotive through the train-pipe when the brakes are released.

14. Q. How is the automatic brake applied and released?

A. The automatic brake is applied by reducing the air pressure in the train pipe at the locomotive, or at any other point, and it is released by restoring the pressure in the train-pipe from the main reservoir on the locomotive.

15. Q. Why does the compressed air not enter directly into the brake cylinder from the train-pipe, as in the straight air-brake?

A. Because the triple-valve used with the automatic brake prevents the air from entering directly from the train-pipe to the brake cylinder when the pressure in the train-pipe is maintained or increased.

16. Q. What other uses has the triple-valve?

A. It causes the brake cylinder to be opened to the atmosphere under each car, and releases the brakes when the pressure in the train-pipe is restored from the locomotive, and it opens communication from the train-pipe to the auxiliary reservoir by the same movement; when the pressure in the train pipe is reduced, it closes the openings from the train-pipe to the auxiliary reservoir and from the brake cylinder to the atmosphere, and then opens the passage between the auxiliary reservoir and the brake cylinder by the same movement, so as to admit the air and apply the brakes.

17. Q. How many forms of triple valves are there in use, and what are they called?

A. Two: the plain triple and the quick-acting triple.

18. Q. How can you tell the plain triple from the quick-acting triple?

A. The plain triple has a four-way cock in it, with a handle for operating the cock; the quick-acting triple has no such cock in it, but there is a

plug-cock in the cross-over pipe leading from the train-pipe to the triple, when the quick-acting triple is used.

19. Q. What are these cocks for in both cases ?

A. They are to be used to cut out brakes on one car, without interfering with other brakes on the train, if the brake on that car has become disabled.

20. Q. How does the cock handle stand in the plain triple-valve when the pipe is open for automatic action ?

A. It stands in a horizontal position.

21. Q. In what position does the same handle stand when the brakes are cut out by closing the cock ?

A. It stands at an inclined position midway between horizontal and vertical.

22. Q. Can this cock handle be placed in any other position, and what ?

A. In the older form of plain triple-valve it can be moved to a vertical position.

23. Q. What was this position for, and is it still used ?

A. This was to convert the automatic brake into a straight air-brake, and it was needed when some cars were equipped with straight air-brake and some with automatic brake, but it is not now used.

24. Q. How does the handle of the plug cock in the cross-over pipe, used with the quick-acting triple, stand for automatic action ?

A. It stands with the handle cross-wise with the pipe, and the cock is then open.

25. Q. How does it stand when the cock is closed and the brake cut out of action ?

A. It stands with handle lengthwise of cross-over pipe.

26. Q. How is the train-pipe coupled up between the cars ?

A. By means of a rubber hose on each end of the train pipe, fitted with a coupling at the loose end.

27. Q. How is the train-pipe closed at the rear end of the train ?

A. By closing the cock in the train-pipe at the rear end of the last car.

28. Q. How many such train-pipe cocks are there to a car, on the air-brake train-pipe and on the air-signal train-pipe, and why ?

A. Two for each pipe on each car, because either end of any car may sometimes be at the rear end of the train.

29. Q. How many kinds of train-pipe cocks are there in use at the ends of the cars ?

A. Two.

30. Q. Describe each and give the position of the handles for opened and closed in each case ?

A. The older form of train-pipe cock is a straight plug-cock in the train-pipe, not far from the hose connection ; the handle stands crosswise with the pipe when it is open, and lengthwise with the pipe when closed ;

Secretary Sinclair—Mr. Gentry is a member of the committee. I have no doubt he will read the report.

The President—Let me say that the report was received too late to be printed.

Mr. Gentry—I am very glad that it has been stated to the members that the report was received too late to be printed. I should like to state for the benefit of myself and other members of the committee that we did not see the report until we got here. A copy of it was sent to me, which reached my office just as I was leaving, and I brought it with me intending to read it on the train. I had a letter from Mr. Barr, the chairman of the committee, regretting that he had not been able to get out a report that would give more information. Speaking for myself, at least, I felt some hesitation in attaching my signature to this report, on account of the fact stated by our secretary—that whenever subjects have been referred back to committees, and committees continued, we generally get a worse report in the last case than we did in the first. I propose to read Mr. Barr's report to the association, and if they choose to receive it, all right. If not, they can appoint a new committee on the subject. Mr. Barr expressed his regret at not having been able to make it differently, but he was very much crowded at the time.

Mr. Gentry then read the report, as follows:

Smoke Prevention.

Your Committee appointed to report in the matter of smoke prevention on locomotives begs to submit the following: Smoke prevention means perfect combustion. The matter of perfect combustion has been discussed, and the principles upon which it depends have been thoroughly established long before the existence of this association. Perfect combustion means: 1. That temperature of the firebox must be maintained at a sufficiently high point to insure prompt combination of the carbon of the fuel with oxygen; 2. An adequate supply of oxygen; 3. Proper presentation of the oxygen to the fuel.

It is unnecessary in this report to go further into detail in the matter of combustion, as full information can be readily obtained from well-known books. It may therefore be taken as an established fact that if the temperature of the bed of fuel is maintained at the proper point, and its efficiency not impaired by the addition of an excess of raw and cold fuel, and if the proper amount of oxygen is supplied, that the prevention of smoke will be accomplished.

We find in practice that the ordinary locomotive with deep

firebox, equipped with fire-brick arch and ten 2-inch combustion tubes, three on each side of the box and two on each end, can be operated practically with no smoke while running. It is understood that the locomotive is fired carefully, the fuel being introduced in small quantities so as not to lower the temperature of the incandescent body of fuel. From the results as to smoke, it may be inferred that when a locomotive is in operation the draft occasioned by the exhaust introduces enough oxygen through the grates and combustion tubes to effect perfect combination with the elements of the fuel, and with the high temperature of the brick arch maintains the gases in the firebox in proper condition to secure perfect combustion. This, however, is not the case when the locomotive is at a standstill. At this time, if the body of the ignited fuel is fully incandescent, no smoke will be produced; but if there is any raw fuel, smoke will manifest itself. Again, if the locomotive stands for some time, causing a decrease in the temperature of the material in the firebox below the point at which a proper combination is effected between the oxygen and the elements of the fuel, smoke will be produced when steam is again turned on.

The matter of smoke prevention, therefore, involves the provision of additional means to meet the requirements of locomotives when at rest and when starting into action. Numerous devices have been arranged for this purpose, the essential basis of all consisting in means for injecting air over the surface of the fire, and any of these devices which furnish air in sufficient quantity over the surface of the fire, the temperature of the fire being properly maintained, will prevent the formation of smoke. Devices of this kind have been in use for at least fifty years. The difficulty in the use of such devices occurs when the temperature of the mass of burning fuel becomes too low; in such cases the device will not prevent smoke, and frequently, by assisting in lowering the temperature of the ignited fuel, will rather foster the formation of smoke than prevent it

If the temperature of the firebox begins to fall below the point at which smoke can be prevented, the difficulty may be avoided by turning on the blower and thus increasing the heat of the firebox. The objection to this practice is its tendency to increase the formation of steam in the boiler and consequent blowing-off

kicked off on the forward end of the train when the engineer closes the valve after applying the brakes.

70. Q. Why does the equalizing engineer's valve produce these results in ordinary service stops?

A. Because the engineer does not, in such cases, open the train-pipe to the atmosphere direct, but he only reduces the air pressure above the piston in the engineer's valve, which causes that piston to open the train-pipe to the atmosphere, and to close the opening gradually when the train-pipe pressure has been correspondingly reduced.

71. Q. What does the excess pressure valve in the engineer's valve accomplish, and do you regard it important to have it working properly?

A. It maintains an excess pressure of about 20 pounds in the main reservoir above the pressure in the train-pipe, and it is important that it be kept clean and in working order so as to have this excess pressure to insure release, and for use in recharging the train quickly after the brakes are released.

72. Q. How often should the brake valve be thoroughly cleaned and oiled?

A. At least once every two months.

73. Q. If the rotary disk valve in the engineer's valve is unseated by dirt or by wear, what may be the result, and what should be done?

A. It may be impossible to get the excess pressure; when the brakes have been applied they may keep applying harder until full on, or when they have been applied they may go off. The rotary disk valve should be thoroughly cleaned, and if worn it should be faced and ground to a seat.

74. Q. If the piston in the engineer's valve becomes gummed up or corroded from neglect to clean it, what will be the result?

A. It will be necessary to make a large reduction of pressure through the preliminary exhaust port before the brakes will apply at all, and then the brakes will go on too hard, and will have to be released.

75. Q. When the engine is standing alone and the pump is running, why must the engineer's valve not be left standing in the lap position (No. 3)?

A. Because the main reservoir pressure may become so high that, when the handle of the engineer's valve is again placed in the release position, it will cause the train-pipe and tender auxiliary reservoir to be charged with too high pressure, which might injure the adjustment of the pump governor as well as cause the tender wheels to be slid with the first application of the brakes.

76. Q. How and why should the train-pipe under the tender always be blown out thoroughly before connecting up to the train?

A. By opening the angle cock at the rear end of the tender and allowing the air from the main reservoir to blow through. This blows out the oil, water, scale, etc., which may accumulate in the pipe, and which

A. The pressure retaining valve is a small valve placed at the end of a pipe from the triple valve, through which the exhaust takes place from the brake cylinder. It is used to retard the brake release on heavy grades and hold the brakes partially applied, so as to allow more time for the engineman to recharge the auxiliary reservoir.

62. Q. What precautions are necessary on every train in regard to hose couplings?

A. Every train must carry at least two extra hose and couplings complete, for use in replacing any hose couplings which may fail or become disabled. These extra hose and couplings to be carried on such part of the train as is required by the rules and regulations.

SPECIAL FOR ENGINEMEN.

63. Q. How should the air pump be started?

A. It should be started slowly, so as to allow the condensation to escape from the steam cylinder and prevent pounding, which is more likely to occur when the air pressure is low.

64. Q. Why should the piston rod on the air-pump be kept thoroughly packed?

A. To prevent condensation in the steam cylinder from running down the rod into the air cylinder and thus getting water in the air-brake service.

65. Q. How should the steam cylinder of the air-pump be oiled, and what kind of oil should be used?

A. It should be oiled as little as necessary through a sight-feed lubricator, and cylinder oil should be used.

66. Q. How should the air cylinder of the air-pump be oiled; what kind of oil, and why?

A. It should be oiled very little by once filling the oil-cup with West Virginia well oil daily. Cylinder oil, lard oil and other animal or vegetable oils must not be used, as their use causes the engineer's brake valve and the triple valves to gum up. The oil must never be introduced through the air inlet ports, as this practice would cause the pump valves to gum up.

67. Q. What regulates the train-pipe pressure?

A. The pump governor.

68. Q. Why should the pump governor prevent the train-pipe pressure exceeding 70 pounds?

A. Because 70 pounds train-pipe pressure produces the strongest safe pressure of the brake shoes upon the wheels. A higher train-pipe pressure is liable to cause the wheels to slide.

69. Q. Why is the equalizing engineer's valve better than the older forms?

A. Because it enables the engineer to apply the brakes more uniformly throughout the train, and with less shock to the train, especially when the quick-acting triple valves are used. It also prevents the brakes from being

principal of which being that the arch would not stand up with the intense heat; and again, where the arch would work successfully with good coal, with poor coal the arch would melt right down. Therefore, I think that any smoke-burning device like a hollow tube and jet, of which most of these smoke-burning devices mentioned are composed, do not burn the smoke or produce more perfect combustion.

Mr. W. H. MARSHALL—As a member of the committee, I wish to state that my position is very much that explained by the others. I do not think that in the report there is anything with which the members want to disagree particularly. They think that it might have been a little more complete. I am very much convinced that the best smoke preventer any of us ever saw is a very good fireman. You can put any device on the locomotive that you please, and if the fireman does not attend to business the locomotive will smoke. If you have a good fireman, and the engine is not perfectly designed, he will probably do good work as a smoke preventer. Some use the steam jet to admit air above the fire, and others use hollow tubes with nothing to propel the air in except the vacuum produced in the smoke-box. I think a number of persons have experimented with that arrangement, and pronounced it a failure because they have failed to take into consideration several facts. For instance, if the grate is of a certain area, and the openings and the depth of the fire are a certain figure, then the openings required will aggregate a certain area. If, however, you change, say, the depth of the fire, going, say, one half as deep, why, then, more of the air is going to come in the grate and less will come through those openings. On the other hand, if you very much increase the depth of the fire or change your grate bars so that the area for air admission is very much less, the vacuum in the smoke-box is going to draw air in from any source you can get it from. Consequently a very much larger proportion will go through these tubes. I have known engines that were fitted up with a certain number of tubes, and those engines were practically the same as others on the road working successfully; but perhaps they were on another division, and the coal was different, and the men handled the engine differently, and perhaps those holes were plugged up, or half of them, and perhaps the engine steamed better.

There is another thing in connection with grates that ought to receive attention. On a number of roads it has been found that a grate pattern which was all right at one time, as far as air spaces were concerned, had gradually thickened up, because the fingers broke or the bars failed in some way, and without very much attention being attached to the subject the air spaces were very much reduced, and I have no doubt but that there are many of these grate-bars to-day giving very much less air space through them than the master mechanic thinks. Regarding hot air, the necessity for heating air to be mingled with the gases above the fire, I am of the opinion that most devices that attempt that are impracticable, and it does not seem to me necessary to heat the air. There is a certain amount of air that can be admitted above a fire, and the temperature of the firebox is

such that it will be heated and will mingle successfully with the gases and those gases will be burnt. If you admit too much, the gas does not combine with the air, simply because the temperature is lower. Therefore, if you will not attempt to admit all the theoretical quantity of air, all air that goes into the firebox will be used in combustion and not in simply reducing the temperature of the box. If, on the other hand, you struggle for too great a perfection you will probably get in more air than can be successfully combined, and your engine will drop off in efficiency instead of the combustion being improved.

Mr. Leeds—I was at Dunkirk yesterday, and among other things that I took note of, and purposed to try, was what I considered a first-class smoke-consumer, and that was nothing more nor less than a grate-bar which struck me as being just about correct. I do not think that the introduction of cold air above your fire indiscriminately, or even under such control as we are able to give it—inasmuch as we do not handle it ourselves—is beneficial. I think a great deal more of the gases are condensed before they are converted into smoke than there are consumed. In the first place, I do not think that you can, by any possibility, receive benefit from any greater amount of air, introduced in any other way, than what can become heated to the degree of ignition. Several years ago, we tried the introduction of tubes from the back end of the firebox through two 4-inch openings on each side of the door just below this pipe, passing up below the arch of the door and down on each side of the firebox and under the brick arch. Those pipes were drilled full of holes of about $\frac{3}{16}$ths, and of course, the pipe being red hot all the while, the air that passed into it was heated to a great extent before passing over the fire, and decidedly it came the nearest to being a smoke-consumer of anything that I ever saw. We ran it for several months, burned out a great many sets of pipes during the time, and never saved a pound of coal that we could any of us find. I had a fireman who would fire as he was told, and took a great deal of interest in it, and he said that if he would allow the same amount of air to pass through his fire properly and ignite at the surface of the fire with his gases, that he could produce the same results in every way; and I am happy to say that he demonstrated it in about four years that he fired for me, and to-day he is as good an engineer as there is in the country, from the very fact that he gave as much interest to his other business as he did to giving the proper amount of air through his fire. I think the proper way is to fire light enough to just introduce the proper amount of air and get it heated to the igniting point before going into your flue.

Secretary Sinclair—The railroads in this country are going through the same requirements and the same necessities in regard to smoke consumption that the leading railroads in Europe passed through about thirty years ago. At that time there was a movement by municipal bodies to prevent railroad companies inflicting the nuisance of smoke upon the country and upon cities. It was carried on so vigorously that the question was either to burn fuel that produced no smoke or to prevent smoke. It was

no idle ordinance or law that was passed. The law was enforced very strictly. The consequence was that railroad companies had to do their best to consume the smoke, or prevent it, or burn coke. Coke was so much more expensive than coal that coal-burning became general, and patentees had made great fortunes in supplying railroad companies with the devices necessary for preventing smoke. Within the last few years municipalities in this country have been stirring up excitement against the usage of smoke, and railroad companies are compelled to listen to them. The effect of this is that our patentees are reproducing the patents of thirty years ago, and, I have no doubt, making a golden harvest from them.

I paid a great deal of attention to the devices for smoke consumption, and I can see nothing now offered to railroad companies that was not in use thirty or forty years ago. After a great deal of experiment and experience with complicated smoke-preventing devices, the railroad companies in Europe dropped down to a few simple arrangements, and that is the common practice to-day—the brick arch and a method of admitting air above the fire. That is considered the best smoke-preventing combination there is—in combination with a good fireman. In no case can the fireman be ignored. I came on the scene shortly after the excitement of smoke prevention in England began. I came on as a fireman, and soon learned that a fireman's life was made very unhappy by those who were after the fellows who raised smoke. It did not matter whether you had a good smoke-preventer or not; you had to prevent smoke, or be summoned to appear before a magistrate. You did not have to go before your superintendent; he did not trouble himself much about that. A constable would come around, and let you understand that you had to have an interview with a magistrate in a day or two if you were raising smoke. Consequently, we were all very active in keeping ourselves out of trouble. At the same time, we were working on the premium system of fuel. We were allowed a certain quantity of fuel for the engine, and whatever we saved we received a premium for it. We were trying to keep out of trouble by preventing smoke, but soon found that the prevention of smoke and the saving of fuel did not agree. If you prevented smoke, you burned more coal. I never knew one case in the whole of the British Isles where this did not follow.

All smoke-preventing patentees offer you their devices on the ground that they save fuel. I have never seen a case yet but that smoke prevention, in a practical way, used up more fuel. You may prevent smoke in laboratory experiments, where you can regulate the supply precisely to suit the demands, and get more heat out of your coal thereby, but if you have to supply your air through the channels necessary to supply the locomotive or a stationary engine boiler, you will use so much air that the tendency is to cool the gases, and on that account you waste fuel. It is well known by those who use smoke-preventing devices on stationary engines, as well as on locomotives, that there is no saving of fuel from it, but it is quite the reverse. At the same time skillful firing, and furnaces well arranged, will keep down the nuisance and prevent trouble with municipal authorities,

ghtly at first, then increasing the brake pressure as needed, and by slowg the train down just before it is necessary to release the brakes for reiarging, so as to give time enough to refill the auxiliary reservoirs before uch speed is again attained.

93. Q. If the train is being drawn by two or more engines, upon which ngine should the brakes be controlled, and what must the enginemen of ie other engines do?

A. The brakes must be controlled by the leading engine, and the nginemen of the following engines must close the cock in the train-pipe ist below the engineer's valves. The latter must always keep his pump inning and in order, and main reservoir charged, with the engineer's valve i the running position, so that he may quickly operate the brakes if called pon to do so.

94. Q. If the air-signal whistle only gives a weak blast, what is the robable cause?

A. Either the reducing valve is out of order so that the pressure is less han 25 pounds or the whistle itself is filled with dirt or not properly adjusted.

95. Q. If the reducing valve for the air-signal is allowed to become logged up with dirt, what will the result probably be?

A. The signal-pipe might get the full main reservoir pressure, and the vhistle will blow when the brakes are released.

96. Q. If you discover any defect in your air-brake or signal apparatus vhile on the road, what must you do?

A. If it is something that cannot be readily remedied at once, it must e reported to the engine-house foreman as soon as the run is completed.

97. Q. What is the result if water be allowed to collect in the main eservoir of the brake apparatus?

A. The room taken up by the water reduces the capacity for holding ir, and the brakes are more liable to stick. In cold weather also the water nay freeze and prevent the brakes from working properly.

SPECIAL FOR ENGINE REPAIRMEN.

98. Q. How often must the air-brake and signal apparatus on locomoives be examined?

A. After each trip.

99. Q. Under what pressure must it be examined?

A. Under full pressure, *i. e.*, 70 pounds on the air-brake train-pipe, 20 ounds excess in the main reservoir, and 25 pounds pressure on the air-signal train-pipe.

100. Q. How will you be sure that proper pressures are upon the two rain-pipes?

A. By regulating, and, if necessary, cleaning the pump governor so hat it will shut off steam from the pump when 70 pounds train-pipe pressire is reached, and by examining, and, if necessary, cleaning the pressure

reducing valve for the signal train-pipe, so that it maintains 25 pounds pressure in the train-pipe.

101. Q. If you do not obtain 20 pounds excess pressure in the main reservoir when the handle of the engineer's valve is in the running position, what is the cause?

A. Either the excess-pressure valve needs cleaning, or the rotary disk-valve in the engineer's valve is unseated and allows air to leak from one port to another.

102. Q. Why must the air-pump piston-rod be kept well packed?

A. To prevent condensation in the steam cylinder from running down into the air cylinder and getting into the brake-service.

103. Q. How often must the main reservoir and the drain-cup under the tender be drained?

A. After each trip.

104. Q. How often must the triple-valves and the cylinders of the driver and tender-brakes be cleaned and oiled.

A. They must be thoroughly cleaned and oiled with a small amount of mineral oil once every six months, and the cylinders must be oiled every three months. If the driving-brake cylinders are so located that they become hot from the boiler, they may require oiling more frequently.

105. Q. If there are any leaks in the pipe joints or anywhere in the apparatus, what must you do?

A. Repair them before the engine goes out.

106. Q. How is the brake-shoe slack of the cam-driver brake taken up, and what precautions are necessary.

A. By means of the cam-screws, and it is necessary to lengthen both alike, so that when the brake is applied the point of contact of the cams will be in a line with the piston-rod.

107. Q. How is the brake-shoe slack of driver-brakes on a locomotive with more than two pairs of driving-wheels taken up?

A. By means of a turnbuckle or screw in the connecting-rods.

108. Q. How is the slack of the tender-brake shoes taken up?

A. By means of the dead-truck levers; if they will not take it up enough, it must be taken up in the underneath connection, and then adjusted by the dead-lever.

109. Q. How far should the driver-brake piston travel in applying the brakes?

A. Not less than one-third nor more than two-thirds of the full stroke of the piston.

110. Q. What travel of piston should the tender-brakes be adjusted for?

A. Not less than five inches nor more than six inches, and such adjustment must be made whenever the piston travel is found to exceed eight inches.

111. Q. How should you proceed to test the air-brakes before starting ɿt, after a change in the make-up of a train, or before descending certain ɔecially designated grades?

A. After the train has been fully charged with air, the engineman ıust be signaled to apply the brakes; when he has done so, the brakes ıust be examined upon each car to see that the air is applied and that the iston-travel is not less than 5 inches nor more than 8 inches, on a passen-er car, or 9 inches on a freight car. The engineman must be then signaled ɔ release the brakes, and this signal must be given by the train air-signal ·om the rear car, if it is in use upon the train; after he has done so, each rake must be examined again to see that all are released. The engineman nd conductor must then be notified that the brakes are all right, if they re found so.

112. Q. In starting out a passenger train from an inspection point, ow many cars must have the brakes in service?

A. Every car upon the train.

113. Q. When might you cut out a brake upon a passenger car?

A. Never; unless it gets out of order while on the run, in which case : must be reported to the inspector at the end of the run, or upon the first pportunity which may give sufficient time to repair it.

114. Q. If a hose bursts upon the run what must be done, if the train ; in a safe place?

A. The hose must first be replaced by a good one, and the engineman ıen signaled to release the brakes. The train must not proceed until the rakes have been reconnected and tested upon the train to see that all are ·orking properly.

115. Q. If the train is not in a safe place when the hose bursts, what ɲust be done?

A. The train-pipe cock immediately ahead of the burst hose must be losed and the engineer signaled to release the brakes. The brakes at the ear of the burst hose must then be released by bleeding the auxiliary res-rvoirs, and the train must then proceed to a safe place to replace the hose nd connect up the brakes, after which the brakes must be tested.

116. Q. If the train breaks in two, what must be done?

A. The cock in the train-pipe at the rear end of the first section must e closed, and the engineman signaled to release the brakes. The two ıarts of the train must then be coupled, the hose connected and the brakes gain released by the engineman. When it is ascertained that the brakes .re all released, the train may proceed.

117. Q. Explain how the pressure retaining-valves are thrown into .ction or thrown out of action, and when this must be done.

A. The pressure retaining-valve is thrown into action by turning the ıandle of the valve to a horizontal position, and it is thrown out of action

again by placing this handle in a vertical position pointing downward. This handle should be placed in a horizontal position at the top of a heavy grade, and it should always be returned to a vertical position at the foot of the grade, as otherwise the brakes will drag on any cars which still have the handle of the pressure retaining-valve in the horizontal position.

118. Q. If the brake of any car is found to be defective on the run, how should you proceed to cut it out?

A. By closing the cock in the cross-over pipe of the quick-acting brake, or in the triple-valve of the plain automatic brake, and then opening the release-cock in the auxiliary reservoir upon that car, leaving it open, if a passenger car, or holding it open until all the air has escaped from it, if a freight car.

119. Q. When it is necessary to cut out a defective brake upon a car, why should it always be cut out at the triple-valve and never by the train-pipe cock at the end of the car, even if it is the last car of the train?

A. The train-pipe should always be open from the engine to the rear end of the last car, so that if the train breaks in two the brakes will be automatically applied before the parts of the train have separated sufficiently to permit damage to be done by their coming together again, and so that the brakes may be applied with the conductor's valve upon any car.

120. Q. Should the train-pipe burst under any car, what must be done?

A. The train must proceed to the nearest switching point, using the brakes upon the cars ahead of the one with the burst pipe, where the car with the burst pipe must be switched to the rear of the train; the hose must then be coupled up to the rear car and the cock at the rear end of the next to the last car opened and the cock at the forward end of the last car closed, so that if the train should part between the last two cars the brakes will be applied.

121. Q. What is the conductor's valve, and what is its use?

A. It is a valve at the end of the branch-pipe leading from the train brake-pipe upon each passenger car; it is to be opened from the car in any emergency when it is necessary to stop the train quickly, and only then. When used it should be held open until the train is stopped, and then it should be closed.

122. Q. What is the air-signal for, and how is it operated?

A. It is to signal the engineman, in place of the old gong signal, and it is operated by pulling directly downward on the cord one second for each signal given and allowing two seconds to elapse between pulls.

123. Q. If the car discharge-valve on the air-signal system is out of order or leaking on any car, how can you cut it out?

A. By closing the cock in the branch-pipe leading from the train signal-pipe to the discharge-valve; to do so the handle of this cock should be placed lengthwise with the pipe.

124. Q. How is the slack taken up so as to secure the proper adjustment of piston travel?

A. By means of the dead truck-lever, and if that is not sufficient, one or more holes must be taken up in the underneath connection and the adjustment then made by the dead truck-lever.

SPECIAL FOR INSPECTORS.

125. Q. Do you understand that no passenger train may be started out with any of the brakes cut out of service?

A. I do.

126. Q. Why is it important that no leaks should occur in the air-brake service?

A. Because they would interfere with the proper working of the brakes and might cause serious damage.

127. Q. What must be done with the air-brake or air-signal couplings when not united to other couplings?

A. They must be secured in the dummy coupling, so that the face of the dummy coupling will cover the opening of the hose coupling, so as to prevent dust and dirt from entering the hose.

128. Q. If air issues from the release port of the triple-valve when the brakes are off, what is the eause?

A. It is probably due to dirt on the rubber-seated emergency-valve.

129. Q. How often must the cylinder and triple-valves be examined, cleaned and oiled?

A. As often as once every six months on passenger cars and once in twelve months on freight cars, and the cylinders must be oiled once every three months with a small quantity of mineral oil. The dates of the last cleaning and oiling must be marked with chalk on the cylinders.

130. Q. To what travel of piston must the brakes be adjusted?

A. Not less than 5 inches nor more than 6 inches, and this adjustment must be made whenever the piston travel is found to exceed 8 inches on a passenger car or 9 inches on a freight car.

131. Q. How is the slack taken up so as to secure this adjustment?

A. By means of the dead truck-lever, and if that is not sufficient, one or more holes must be taken up in the underneath connection and the adjustment then made by the dead truck-lever.

132. Q. What are the different holes in the outer end of the cylinder-levers for, and why must the connections be pinned to the proper hole for each car?

A. These holes are to enable the adjustment of the brake pressure to be made according to the weights of different cars. The connection must be made to the proper hole in each case, according to the weight of the car, so as to give proper braking power; otherwise the brake will be inefficient, or the wheels may be slid under the cars.

On motion of Mr. Briggs the report was received.

of them, why out they come, and we take the jacket off and sound the whole of them then.

Mr. GENTRY—I believe where the best practice prevails and the most success is obtained in locating broken stay-bolts is where they test the flues with pressure on the boiler. We do that. We have an idea that by expanding the sheet with pressure, if there is a broken bolt we will get the sheet forced sufficiently away from the contact with the bolt to locate it better even than with the hammer test itself. It is our practice to test our bolts as often as we can. Mr. Brown says that they wash their boilers about once in a month or five weeks. We wash our boilers every round trip. We never think of allowing a consolidation engine or a ten-wheel engine to go longer than that. Our freight engines run from Richmond to Atlanta, Georgia, 560 miles in one direction, and back. That is a round trip with those engines. We of course wash the engines every time they make a round trip. The passenger engines' run is shorter, and we wash them about every two trips. That is one reason why we have made such a preparation for washing boilers, and I think our practice will probably compare very favorably with that of almost anybody else, because we have a large amount of boiler washing to do, and it has paid us to go to a great deal of trouble.

Mr. Mackenzie says that we are ignoring the stay-bolt business. I would like to know if it is not rather more general practice to test bolts with a sufficient pressure on the boiler to help in locating? We have got an idea in our shop, that if there is a broken stay-bolt, and a contraction happens to take place, the parts are very close together, while if we have a pressure there we force them apart a little bit.

The PRESIDENT—Mr. Barnett, will you address the Convention on this subject?

Mr. BARNETT—I doubt if I have any contribution of any interest to make to this discussion. We wash out with hot water. I suppose almost all of you are doing that to-day. We run the water out of the boiler into a hot well, seeing that the washing out is done with a pump and not by a boiler-washer. The testing of the stay-bolts is done when the engine is cold. I certainly feel like suggesting to our people that they see what value there is in testing them while the boiler is warm. I have not tried it in my own practice, and therefore cannot give an opinion as to its value. Theoretically I should think that that was the better practice.

Mr. MITCHELL—There is a great deal of difference, I find, in our practice in locating broken stay-bolts. We had occasion to make a test the other day. We had to remove a firebox from a locomotive. That locomotive was sent to the shop and a sketch was made of every stay-bolt in the boiler and the exact location. Then the inspectors from that territory covering all the shops were sent to this point and they were asked to sound those stay-bolts, and give the man who had charge of the drawing every broken stay-bolt in the boiler. After all the inspectors had sounded the stay-bolts from that boiler and had located every broken stay-bolt, the fire-

Mr LAUDER—I move that the report be received and its recommendations adopted.

Mr. FORNEY—I would like to amend by adding that a Committee on the Economy of Simple Engines be appointed to report next year.

The PRESIDENT—I think I will have to rule that out of order, Mr. Forney. We have got more subjects now than we can handle. I heard no second to Mr. Forney's motion, however.

Mr. Lauder's motion was then put and carried.

The Committee on Resolutions, through Mr. Marshall, presented the following report:

REPORT ON RESOLUTIONS.

Resolved, That the thanks of this convention be given to the Village of Saratoga, and to its president, Mr. Mitchell, for the cordial welcome extended to us ; to the Schenectady Locomotive Works, and to the Delaware & Hudson Canal Co., for the pleasant and instructive visit to the shops of the former company by so many members ; to Mr. R. C. Blackall, superintendent of motive power of the Delaware & Hudson Canal Co., and to Mr. H. G. Young, second vice-president of the same company, for their assistance in making arrangements for the convenience and comfort of the members while at Saratoga, and for courtesies extended to members in the way of transportation ; to the Fitchburg Railroad Co., for the transportation facilities extended to them through Mr. O. Stewart, superintendent of motive power ; to our friends who have furnished such unexcelled entertainment to the members and their ladies ; to the *Railway Age* and *Northwestern Railroader* for daily reports of the proceedings of the convention ; to the officers of the association for their earnest work, and the efficient manner in which all the business of the association has been handled during the year, and to the proprietor of Congress Hall for his successful endeavors to make our stay in Saratoga a pleasant one. And be it further,

Resolved, That the hearty thanks of this association be extended to the Chicago, Milwaukee & St. Paul Railway Company, for its liberality in providing facilities for the testing of such locomotives as the committee of this association desired to place under trial ; to the Baldwin Locomotive Works, for the assistance which they rendered the same committee, and to all others who have improved and broadened the work of our association by cooperating with its committees. W. H. MARSHALL.

we can't keep that water to a proper temperature always. We aim to do it, but we do not do it." I notice that is the case with most plants where they claim to wash with warm water.

In the matter of stay-bolt inspection, of course we require a daily inspection for broken stay-bolts, but we also have a monthly inspection, and we have a blank prepared for the purpose, on which the men are required to report this monthly inspection, giving in their judgment the number of broken stay-bolts that they found at the time by the monthly inspection. I had two engines at an outlying point where the man who was supposed to do this work was not very successful, and he reported one of these engines as being examined in the regular monthly examination, and reported only five stay-bolts broken at the time that he made this examination. Two days after this report was made I had occasion to bring the engine to the shop, and an examination was made by our regular inspector, and we found over two hundred broken stay-bolts in that boiler. That showed that we are dependent upon the judgment and skill of men who are not always competent to judge of these questions, and as Mr. Mitchell explained where he collected all the inspectors within a certain range on his road and conducted this test, there is a great variation in the judgment of the men as to the bolts that are broken and the bolts that are not broken. I think that the move made by Mr. Mitchell was a very good one, and if it were practiced by all roads it would be a great benefit. It would educate the men up to a better knowledge and a better judgment of the condition of broken stay-bolts.

Mr. Gillis—One of our superintendents of motive power, Mr. Sanderson, has just made extensive experiments in regard to testing stay-bolts, spending two or three months altogether, making a study of the matter with inspectors and in every way he could. The conclusion he reached would substantiate what Mr. Mackenzie said, I think, that the test with a slight steam pressure for the stay-bolts is the best test. We had some very old inspectors who were considered very expert, but when they tried to test the stays with the water in the boilers they did not seem to be very expert, as they found hardly any of the broken stay-bolts that were broken, but nearly all of them were able to detect a large majority of the bolts when the boiler was tested with a slight pressure in. I think that we can combine to good advantage the washing out and the testing of stay-bolts. I believe that a boiler can be washed out more quickly and fired up in the method suggested by Mr. Gentry, but I think the safety of the boiler of far more importance than the quickness of washing out.

Mr. Leeds—I boiled my men by putting them in the boiler until my sense of humanity caused me to discontinue the practice. I found that I was finding more stay-bolts broken when the engine came into the shop than there were under the old system of the water-pressure. I am now applying the principle of compounding to my inspection. I pump into one reservoir, and then take the air from that with another pump and pass it over into another chamber. I double the power of my pump. In other

words, I can pump up to 120 or 130 pounds pressure in my second reservoir with an ordinary pump. I propose to apply the air-pressure to all boilers where we can give them a thorough inspection, and after trial I find that they discover more stay-bolts in that way than they do with the water-pressure and decidedly more than they did with the steam-pressure where they were liable to blister themselves all up.

But the principal thing I wanted to say is, that for years, in fact on the entire system, before I took it as a system, there had been a practice in vogue that I think is a good one, and that is, we stop all our lag above the top row of stay-bolts on both sides the entire length of the outside of the firebox, and at the base of that we rivet on a strip of iron with small quarter-inch studs, and from that down we have a sheet continuing the jacket from running-board, both into the cab and outside, and by taking off a few nuts on each side we can take these sheets off. We can hold on the dolly-bar at any time without moving any of the rest of our jacket.

Mr. GENTRY—It seems to be the general impression that it is an advantage to have the pressure in the boiler when you are going to test the stay-bolts. Am I to infer from what Mr. Gillis has said, that there is a difference in the density of the sound when the boiler is under pressure, and when it is not under pressure?

Mr. GILLIS—The idea is, that the water forms a connection between the two broken parts and makes a difference in sound.

Mr. GENTRY—Then I do not see why Mr. Leeds' idea of using air is not as good as using steam. We have tried this system ever since, and we have very low fireboxes with long arches and the engines are long, and they never get cool enough, hardly, for a man to go in there and remain there long enough with his wits about him to make a sufficient test. We did not consider that it was humane, either, to cause a man to go in there under those circumstances. In fact, we had a man who died of pneumonia, which was superinduced by what he had to do—a matter about which I felt somewhat conscience stricken. We commenced to use warm water. Our boiler is never so warm but that you can put your hand against it. In fact, we do not let our boiler get cold at all, if we can help it—at least, those in regular service. They never get dead cold, unless we have some big work on them. We had an excellent opportunity there to demonstrate what Mr. Lewis called our attention to about blowing the water out of our engine with quite a high pressure of steam on. Our water is mostly pumped from rivers, and it is nearly all muddy, and we have cut sections from tubes that have been removed and we have cut little sections from boiler plates that have been removed. I believe with a microscope a man could detect the number of times the boiler had been allowed to dry off; the little layers are so separate and distinct, and they often show difference in color where the engine has been in different localities and using different water.

Mr. McINTOSH—I failed to hear any of the members speak of experience with drilled stay-bolt holes. It is my impression that in the ordinary

methods of testing the bolts we are depending entirely too much on the skill of the inspector. One inspector may be well qualified in that respect, and another quite indifferently qualified, and the results obtained would, of course, correspond with the skill of the respective inspectors. I know from a long experience with the custom of drilling bolts that, if followed up, it will produce more satisfactory results. You would know for certain whether your bolt was broken or not if you drilled, and you do not know under any other circumstances. I had occasion to drill stay-bolts in a firebox that had been tested by skillful inspectors, with the result of finding, I may safely say, a dozen of bolts broken on each side that could not be detected by the best inspector we had. I think if we take into consideration the amount of time that is wasted in testing these engines hot and under different conditions, if the time was so applied toward drilling the bolts, we would have more satisfactory results.

Mr. PURVES—Our method of washing boilers is similar to that followed by Mr. Leeds and some of the other members, and, so far, I am happy to say that we have not a stay-bolt on our line but what is drilled. Our method of inspection is very simple, indeed. We know a stay-bolt leaks and we take it out; that is all there is to it. We have no hammering, no dolly-bar holding, no water pressure, no steam pressure, only air pressure. Our jackets are fastened similarly to the practice followed by Mr. Leeds, and every three months the jackets are removed and every stay-bolt exposed. Of course, I do not mean to say that we remove stay-bolts only once in three months. Our locomotive inspector in the engine-house during his inspection, if he sees a little crust forming over the end of the bolt, he reports it to our foreman boiler maker. The engine then is fired up, perhaps, ready to go out. Our foreman boiler inspector looks at it, locates it, and the engine is ordered to come in and fire-dump the following trip. The stay-bolt is removed. This, understand, is with reference to the stay-bolts that show below the jacket. When the three months comes around, the jackets are removed, and if there is any indication of a crusting at the end of the stay-bolt that stay-bolt is also removed. We feel very safe in regard to the condition of our stay-bolts. If the inspector detects a stay-bolt with water oozing from the hole, we conclude that the stay-bolt is broken. The engine is not allowed to leave the roundhouse for the trip. She is immediately taken to the dump-pit, the steam and water are blown out, and that stay-bolt is removed. So we can go home and rest every night quietly and comfortably, knowing that we have not a broken stay-bolt on the line.

Mr. GENTRY—Mr. President, that sounds mighty nice. We have got engines on portions of our road that run into our shops at Manchester that were built about twenty years ago. Some of them have got their original fireboxes, and we have never gone to the expense and trouble of drilling all those stay-bolts out. For the last few years we have not had any engines built that have not drilled stay-bolts or hollow stay-bolts. But we have got about thirty engines to take care of, about which I hardly ever go to bed at night without feeling some uneasiness. That is the kind of experi-

ence that most men are having and suffering. It is not where we have these nice kid-glove arrangements. We have a certain amount of that, and are getting more of it.

Mr. FORSYTH—Our practice corresponds with what has just been described in drilling stay-bolts on the outside. We have entirely abandoned the regular inspection of the stay-bolts on engines in service, but a special examination of stay-bolts of locomotives in service must be made once a month. Inspectors are required to use special care in seeing that the holes in stay-bolts are thoroughly cleaned. During the inspection there must not be less than thirty pounds steam pressure on the boiler. A locomotive having one or more stay bolts broken in the top row, or two or more in any other row, must not remain in service. The holes in the ends of all stay-bolts must be thoroughly cleaned out when engine is in shop for repairs. Each master mechanic must keep a record of boilers tested and inspected, giving the age of the boiler, the date tested, date inspected, the name of the inspector and remarks on the general condition of the boiler.

The PRESIDENT—It is now approaching the end of the noon hour and we will now have to proceed with the regular order of business. The next thing in order is the report of the Committee on Tender-Frames.

Mr. R. C. Blackall read the following report :

TENDER-FRAMES.

Your Committee, appointed at the last Annual Convention held at Saratoga, to report on the best form of tender and truck-frames of wood and iron, respectfully submit subjoined report :

The following interrogatory circular was issued :

1st. What is your preference, iron or wood, for tender-frames?

2d. Have you adopted a standard tender-frame of wood or iron?

3d. With iron tender-frames, how long have they been in service, and have you experienced any difficulty with rivets becoming loose?

4th. What is your preference for material in tanks—iron or steel?

5th. What is the capacity in gallons of your standard tank?

6th. Please give a description or blue-print of your standard tender-truck, and state whether you use center and side bearings on both trucks?

7th. What is the size of your standard axle and journal for tender-trucks?

8th. What material do you prefer for axles, and what are your reasons for the preference?

Any further information pertinent to these questions is respectfully solicited.

To the circular we have received thirty-nine replies, representing 62,868 miles of railroad and 12,526 locomotives. We do not think it advisable to take time and space to give each answer in detail, but will condense them as much as possible.

To question No. 1, eighteen have preference for wood, eighteen for iron, and three have no choice. The eighteen preferring wood represent 35,398 miles and 5,738 locomotives. The eighteen preferring iron represent 22,023 miles and 5,571 locomotives. The three having no choice represent 5,447 miles and 1,217 locomotives.

Of the number preferring wood, seven have had no experience with iron, three have used iron and had no serious difficulty, two say they are very expensive to maintain, one does not like them, and one thinks a good iron frame can be made. The following roads have adopted it as a standard, and give us cost of construction, as follows:

Del., Lack. & Western, Scranton, Pa	$225 00
Baltimore & Ohio	190 50
Union Pacific R.R	185 00
Pennsylvania R.R	160 00
Delaware & Hudson	150 00
Wisconsin Central	145 00
Canadian Pacific	115 00
Illinois Central	101 77
Chicago, Rock Island & Pacific	92 00
Pennsylvania & Northwestern	89 00
Ohio & Mississippi	68 00
Philadelphia, Wilmington & Baltimore	32 33

Of the eighteen who prefer iron tender-frames, thirteen have adopted it as a standard, one is using wood, and four do not answer the question. The cost of construction is given by only four, and is as follows:

New York, Lake Erie & Western	$365 00
Boston & Albany	280 00
Lake Shore & Michigan Southern	204 52
Del., Lack. & Western, Kingsland, N. J	200 00

In answer to question No. 3, one gives length of service as 16 years, four as 12 years, two as 11 years, one as 10 years, one as 8 years, three as 7 years and two as 6 years. Five say: "Have had no trouble whatever with loose rivets." One says:

The PRESIDENT—Gentlemen, I know of no business to come before this association except that of adjourning.

I would like to take this occasion to thank you for the liberal support which you have given me during my occupancy of the chair, and if I have committed any errors, they have been of the head and not of the heart. (Applause.)

Mr. SETCHEL proposed three cheers for Mr. Mackenzie which were heartily given.

Mr. LAUDER—The best presiding officer we ever had.

The PRESIDENT—I thank you again, gentlemen.

I regret very much that Mr. Hickey has not been with us.

I am grateful for your leniency to me, particularly in respect to the noon hour. If the noon hour discussion had been insisted upon I would have had no chance for rest. I am very grateful for the support that you have given me, and the other officers are thankful for all that you have done. If it were not for the continued kind feeling that you exhibited toward me I could not have handled the convention as I did. I may have ruled a little arbitrarily at times perhaps ; but as I said before, it was a fault of the head and not of the heart.

On motion of Mr. SPRAGUE the convention then adjourned.

driven, some seven years ago, to design one for ourselves. We now have a very heavy steel tender-frame, which we think is a very good one. I am sorry to see that the committee did not get a chance to consider it. We do not make any difference between a tender-frame for a passenger engine and for a freight engine; we use just the same thing. We have also a very substantial arrangement in connection with what Mr. Barnett says—this is on the other subject—for the safety-chains. I will take pleasure in sending prints to any of the members who will ask for them.

Secretary SINCLAIR—I would like to explain about the blue-print matter. The roll of blue-prints came into the hotel within the last day or two. It is particularly large. I did not see that there would be enough wall space to put them all up here, so I thought it would be more satisfactory if I took them and consulted with the Executive Committee to see what would be engraved and what would be left out. It is impossible to engrave all these frames, but if any gentleman is interested in the examination of the prints, I will be very glad to have an interview with him after dinner.

Mr. BROWN—There is one little remark I wish to have understood. These tender-frames made for passenger engines were made previous to the adoption of the one that we intended as a standard, and they cost $225. But the standard is one that has been gotten up since, and we figured that at $200. That is the cost of it.

Mr. MACKENZIE—I move that the discussion be closed.

The motion was carried.

The PRESIDENT—I wish to ask the secretary if he has any further communication that he desires to present at this time?

Secretary SINCLAIR—That finishes the regular reports. I have a report here on Locomotives in Argentine, prepared by a member of this association who is a mechanical superintendent there. It has been considered by the Executive Committee and decided as suitable for submission to this association. The subjects brought in are, however, not of a character suitable for discussion, and it occurs to me that it would suit the interests of all parties just as well if it was printed in the report and allowed to appear in the report without being read—a thing which has been done on several occasions.

Mr. MACKENZIE—I move that the report be received and printed in the proceedings.

The motion was carried.

LOCOMOTIVES IN ARGENTINE.

The following are extracts from a report made recently to the president of the department of engineers of the railroads of the Argentine Republic, made by a member of our association and other experts. The report gives a comparison of English and American locomotives which ought to be interesting to the members of this association. The Western Railway of Argentine,

which had an equipment of rolling stock made in the United States, obtained control of the Southern Railway of Argentine, which was entirely equipped with rolling stock made in England. The object of an investigation made, was to find out the relative value of the two kinds of rolling stock. We quote from the report:

"All the rolling stock of the Southern Railway was manufactured in England. As regards quality of material and its strength, it is all that could be desired; but the builders did not take into account the character of road-bed and track on which it was to run, and, therefore, made it too heavy, and the wheel-base too rigid.

"The locomotives might have run well enough on European roads, which are substantially built and well ballasted; but such is not the case in this province, where most of the railways are built on loose soil, especially those of this company, and subject to frequent inundations.

"The result is a large increase in the cost of maintenance of way and repairs to rolling stock, and, consequently, a heavier burden on the income of the road, and a proportionate reduction of interest on capital.

LOCOMOTIVES.

"Class 5 (Beyer, Peacock & Co., Manchester).—These locomotives were intended for the express trains running between Buenos Ayres and Mar del Plata; but the results of their trial trips were so unsatisfactory that the company was compelled to use them for ordinary passenger service.

"These locomotives have a single driving-axle, Crampton system, and the adhesive weight upon it is 29,392 pounds, or 14,696 pounds upon each wheel. This, even with a working pressure of 160 pounds per square inch, is insufficient to obtain adequate tractive power. This should have been borne in mind, as the trains to Mar del Plata are generally composed of fifty to sixty axles; that is to say, a weight of 350 to 400 tons.

"Practical experience has demonstrated that the locomotives built for this service should have two-coupled axles, and an average weight of not less than 8 tons upon each wheel, to afford adequate tractive power. Although this weight appears to be excessive, it is necessary to give steadiness to the locomotive when

running at a high rate of speed. At the same time, the weight of the train mentioned above should be taken into account, as well as the kind of road and the resistance of the prevailing high winds to the surface presented by a train of this class.

"All these reasons lead us to believe that this point was not sufficiently studied by the engineers of the company when building the road, and when ordering the locomotives. The Crampton type of locomotive is applicable to trains of less weight than it is to the interest of the company to run. None of the centers of population traversed by the lines of this railway is in condition to require the service of very rapid trains, but of trains running at a moderate rate of speed, and keeping exact time.

"Examining the weight of the locomotive, the unequal distribution upon each axle will be noticed, and the effects of this will be noticeably injurious to the permanent way. The high pressure, 160 pounds per square inch, at which the boiler is worked, becomes necessary to overcome somewhat the lack of adhesion. From close observation, we have noticed that this kind of locomotive, when running at less than usual speed and against a moderate wind, so easily primed, and to such an extent, as to make further running impossible.

"Class 6 (Beyer, Peacock & Co., Manchester).—This class of locomotives is fitted for the service of passenger and mixed trains.

"Of all the locomotives owned by the company, these are the most suitable for the road; but even these show the weight imperfectly distributed, there being an excess of more than 10,373 pounds on the bogie. The system of supports is inferior. While the absence of equalization permits of replacing the springs more readily, it has the disadvantage of making it impossible to distribute the shock due to inequalities of track. They have, moreover, a swing-bar which connects the two fore springs—a system which has been abandoned owing to its inefficiency.

"The excessive pressure at which the boilers are worked necessitates frequent and important repairs, such as the renewal of most of the tubes and stacks. The tube-plates and the fireboxes are destroyed in a short time, notwithstanding the good quality of the material, owing to the high pressure of 160 pounds per square inch, although higher pressure should be admissible without doing injury.

W. F. TURREFF.

William Fleming Turreff was born of Scotch parents at Toronto, Ont., April 20, 1834. He learned the machinist trade in his native town and soon after finishing his apprenticeship he went to Buffalo, N. Y., and worked in a marine engine works. At that time railroad machinery was considered of secondary importance compared with the appliances connected with water transportation; but it was every year advancing in consequence, and ambitious mechanics began to turn their eyes to railroad machinery, as the coming era in the great problem of transportation.

Mr. Turreff entered railroad service in August, 1853, with the Cleveland & Columbus Railway, as machinist, at Cleveland, O.; May to September, 1863, gang foreman, Bellefontaine & Indianapolis, Galion, O.; September, 1863, to March, 1864, gang foreman, Cleveland & Columbus Railway, Cleveland; March to August 15, 1864, gang foreman, Wabash & Western Railway, Springfield, Ill.; September 1, 1864, to March, 1865, gang foreman, Cleveland & Pittsburgh Railroad, Cleveland; March, 1865, to May, 1866, foreman, Cleveland machine shops, same road; March, 1866, to September, 1874, general foreman, locomotive and car shops, same road, Cleveland; September, 1874, to 1879, master mechanic and car builder, Cleveland, Tuscarawas Valley & Wheeling Railroad; 1879 to December 31, 1880, train master, same road, in addition to above duties; January 1st to March 27, 1881, superintendent, Indianapolis Division, Cleveland, Columbus, Cincinnati & Indianapolis Railroad; March 27, 1881, to 1890, superintendent motive power, same road; November, 1890, to January 17, 1892—date of his decease—assistant-superintendent of motive power, New York, Lake Erie & Western Railroad. Owing to the serious illness of Mr. Ross Kells, Mr. Turreff had entire charge of the mechanical department of the whole Erie system six months prior to his decease. Cause of death, pneumonia, after an illness of four days at the Hotel Imperial, New York.

Quiet and unassuming, faithful to every trust, he left a host of real friends. Cheerful and kind to all, he had the advantage

of most men in dealing with those under him, always having a kind word for all ; and his good sense and ability of smoothing down the rough pathways of life, encouraging those that felt aggrieved and binding up the bowed down.

Mr. Turreff leaves a wife and one daughter, who have the sympathy of hosts of friends in their loss. He was a prominent member of the Master Car Builders' and of the Master Mechanics' associations and took a warm interest in the work done by those organizations.

WILLIAM FULLER.

space of 61.4 inches from center to center between the driving-axle and the fore coupled-axle, whereas the distance between the rear coupled-axle and the driving-axle is 99 inches. In effecting the distribution of weight, the aim should be to make it as even as possible, in order to avoid greater stress on some parts of the track than on others, thus keeping down the cost of repairing it; but in this case not only has this been overlooked, but the error has also been committed of not having made equal the distances between the centers of the axles and of making them shorter at the point where the traction is more powerful.

"The Southern Railway has no grade so heavy as might compel it to adopt these types of locomotives, the disadvantages of which are seriously detrimental to its interests. The load of weight per square centimeter of surface of these different types of locomotives may be summed up thus:

Class 6	638 pounds.
Class 7	620 "
Class 7 A	638 "
Class 7 B	765 "

"These weights can be borne by roads or track built on hard wood sleepers and ballasted with stone or gravel, because such roads facilitate the distribution of weight over the whole track and are dry at all seasons; but the same cannot be said of the roads of this country, which are built with the Livesay bearings and on the natural ground, most of which is very compressible, so that the use of said locomotives on these roads occasions an increase of 60 per cent. in the cost of repairs to road-bed, besides hastening the destruction of rolling stock as a consequence of the bad condition of the roads.

AMERICAN ROLLING STOCK.

"The American rolling stock is much more suitable for our roads, because of the similarity in the construction and the nature of the ground in the United States and our country, and because of its simplicity, reduced weight, and improved system of equalization. Moreover, it costs less, and necessitates much less expense for keeping it in repair than the European stock.

"The American locomotives owned by the Western Railway, which were acquired when this road was the property of the State, by the engineers, Messrs. Miguel Tedin and Luis Rapelli,

WILLIAM SMITH.

William Smith, superintendent of motive power and machinery of the Boston and Maine Railroad, died of heart failure at his home in Lawrence, Mass., January 19, 1892. Mr. Smith was born in South Berwick, Maine, October 9, 1827, and at an early age entered the machine shop of the Great Falls Manufacturing Co., at Great Falls, N. H., to learn the machinists' trade. In April, 1849, he became identified with the Boston & Maine Railroad, first as machinist in the engine repair shop at Boston, where he served one year. He next served as locomotive fireman for three months, at the end of which period he was promoted to the position of engineman, where he remained for upward of twenty-three years. He was next made engine dispatcher and after six years' service in that position he was made master mechanic in May, 1879.

When the Boston & Maine leased the Eastern Railroad in December, 1884, he was appointed superintendent of motive power and machinery of the combined roads, which position he held at the time of his decease. He was twice married and with the exception of a widowed sister who made her home with him, leaves no immediate family. He had served as a member of the Common Council and the Board of Aldermen in the City of Lawrence, being president of the Board of Aldermen for three years, and had been in the past actively identified with the fire department of that city. He was a member of the Royal Arcanum and a prominent Mason, a member of the Phœnician Lodge, Mt. Sinai Chapter and Bethany Commandery, all of Lawrence. Mr. Smith had slight advantages of education and was essentially a self-made man. Bereft of his father while a boy of tender years, it fell to his lot to become the mainstay of a large family, and nobly he performed his task. He was plain and blunt of speech, but the rugged exterior covered a generous heart which was ever ready to respond to the appeal of charity. A man of positive ideas, he was a master of his chosen profession, and he will be sadly missed by those with whom he was associated. He became a member of the American Railway Master Mechanics in 1880.

EDWARD E. DAVIS.

"In tractive power the American locomotives are first-class, and, with trains composed of twenty-five parlor cars, they have developed a speed of fifty or sixty kilometers an hour, and a higher speed could have been attained, had it been desired, and had the state of the road permitted. The distribution of the weight over the axles is even in all, and this is one of the good features combined in them. So far their boilers, during their three years' service, continue in a perfect state of preservation.

"The repairs they have to undergo are inconsiderable, and confined only to the renewal of the bearings and the turning of the tires.

"Class 15 (Baldwin Locomotive Works, 1889).—For freight trains.

"These locomotives, like the preceding, are very good; their work and preservation are unsurpassed in good results. The weight on the axles is also even on all of them, this being one of their best features for our roads.

"It may be concluded, from all the data furnished in this report, that the Southern Railway locomotives are but iron masses, entirely injurious to the roads and interests of this company, and that a large part of its rolling stock is unnecessary for the service of its lines, as neither the condition of its roads nor the necessities of its traffic require it.

"Many years will elapse before it will be necessary to run very rapid trains on the roads of this province, and yet this company owns five locomotives (Class 5) for this service, which it is at present compelled to have laid by, having no use for them, and being obliged to pay the interest on the capital which they represent, out of the product of work which is not shared by them.

"So unfavorable has been the result of the compound locomotives (Class 6 A), that it was necessary to withdraw them from the Mar del Plata service last summer, and to use in their place the freight locomotives, owing to the tractive power of the former being less than was required.

"We think that the foregoing report is sufficiently specific to enlighten the president, and to justify us in asking him to decree that no company be allowed in future to import into this country their locomotives, without first presenting and submitting their plans to the approbation of this department."

TABLE SHOWING THE COMPARISON OF ENGLISH AND AMERICAN LOCOMOTIVES IN THE ARGENTINE REPUBLIC.

	Built by Beyer, Peacock & Co., Manchester, England.						Baldwin Locomotive Works.		
	Class 5.	Class 6.	Class Compound.	Class 7.	Class 7 A, Compound.	Class 7 B, Compound.	Class 11, 1884.	Class 14, 1889.	Class 15, 1889.
Diameter of cylinders (inches)	16.4	16.4	H.P. 16.4	18.	H.P. 16.9	H.P. 18.1	15.	17.	18.
Diameter of cylinders (inches)	......	......	L.P. 23.2	......	L.P. 24.4	L.P. 26.	......	......	......
Stroke of piston (inches)	24.	24.	24.	24.	24.	26.	20.	24.	24.
Heating surface of firebox (sq. feet)	85.	86.	85.	86.	86.	117.	77.2	119.	96.1
Heating surface of tubes (sq. feet)	929.	984.	929.	990.	1,000.	1,153.	826.7	1,169.	1,076.6
Diameter of driving-wheels (inches)	76.7	68.	68.	61.4	61.8	55.5	60.	72.	54.
Diameter of carrying-wheels (inches)	49.	......	......	......	......	......	......	......	......
Diameter of truck-wheels (inches)	38.	38.	38.	39.3	41.	38.	36.	36.	29.3
Weight upon driving-axle (pounds)	29,392.	24,723.	25,814.	25,286.	25,124.	26,739.	24,301.	30,725.	22,110.
Weight upon carrying-axle (pounds)	20,444.	......	......	......	......	......	......	......	......
Weight upon first-coupled-axle (pounds)	......	24,501.	25,540.	24,054.	24,662.	26,846.	24,301.	30,725.	22,110.
Weight upon second-coupled-axle (pounds)	......	......	......	24,957.	26,210.	24,646.	......	......	22,110.
Weight upon truck-axle (pounds)	36,665.	35,096.	39,281.	20,444.	33,719.	33,719.	24,301.	30,725.	22,110.
Total weight of engine in working order (pounds)	86,501.	84,320.	90,635.	94,741.	109,715.	111,948.	73,903.	92,175.	88,440.
Maximum pressure of steam (pounds)	......	160.	175.	155.	175.	175.	135.	135.	135.
Weight per square foot of surface (pounds)	......	638.	638.	620.	638.	696.	462.	572.	462.
Average consumption of coal per train mile (pounds)	34.	37.	34.6	51.5	38.	39.7	24.8	30.1	43.3
Average mileage per month (miles)	2,485.	2,795.	2,981.	2,485.	1,553.	1,553.	2,485.	3,105.	2,173.
Cost on board in the port of Buenos Ayres	$14,238.00	$14,238.00	$15,483.00	$16,279.00	$16,667.00	$17,967.00	$8,200.00	$11,750.00	$12,125.00
Cost of keeping two years in good repair	$1,800.00	$1,800.00	$1,800.00	$1,950.00	$1,950.00	$1,950.00	$500.00	$500.00	$500.00

The PRESIDENT—The next will be the report of the Committee on Subjects.

Secretary SINCLAIR—Mr. President, the Committee on Subjects submits the following report:

SUBJECTS FOR NEXT CONVENTION.

1. What method of construction can be devised to prevent the cracking of the back tube-sheet?

2. Devices to facilitate the oiling of fast passenger engines when on long continuous runs; and effective cylinder lubrication with high-pressure steam.

3. The value of locomotive fire kindlers and their relation to fire insurance risk.

4. Exhaust nozzles and steam passages.

5. Standard specifications and tests for boiler and firebox steel to be recommended for adoption by this association.

6. Modern sanding devices.

7. Special shop tools, either hand, power, pneumatic or electric, applied or applicable to locomotive manufacture and repair.

8. The recommendation of a uniform system of examination and test of boilers in actual service, more especially for the discovery of broken stay-bolts.

9. Tire treatment—what is the amount of shrinkage to be allowed for large driving-wheels? Is there any necessity for tire retaining rings or clips? What is the limit of thickness that various diameters of tires should be worn down to before being scrapped? What is the greatest allowable depth of groove worn in tread before tire should be turned up in lathe?

WM. SMITH,
E. M. ROBERTS,
J. DAVIS BARNETT,
Committee.

Mr. LEWIS—I move that the report be received and referred to the Executive Committee.

The motion was carried.

The PRESIDENT—I wish at this time, gentlemen, to announce the Committee on Subjects for the ensuing year. They are: Mr. Mitchell, Mr. Barnett and Mr. T. Purves, who will consider the subjects that they will present here one year hence. Is the report of the Committee on Resolutions ready?

The report of the Committee on Resolutions was read by Mr. Pomeroy as follows:

REPORT ON RESOLUTIONS.

The thanks of this association are due and are hereby tendered to the New York, Lake Erie & Western Railway, the Western New York & Pennsylvania, the Chautauqua Lake Railway, the Brooks Locomotive Works, *The Railway Age and Northwestern Railroader*, the Chautauqua Assembly, Mr. Sampson Fox, Mr. George Royal, the proprietors and management of the Kent House and of the Sterlingworth Inn, the officers of the association, Messrs. Sibley and Miller, and to Messrs. A. E. Mitchell and S. Higgins, of the motive power department of the New York, Lake Erie & Western Railway Company.

L. R. POMEROY,
G. R. HENDERSON,
R. D. WADE,
Committee.

Mr. MACKENZIE—I move that the report be received and spread on the minutes.

The motion to receive the report of the Committee on Resolutions was carried.

CHANGE OF BY-LAWS.

Secretary SINCLAIR—It is necessary to change one of our by-laws. Two years ago, I think it was, we arranged with the Master Car Builders' Association that they should meet on the second Wednesday of June and we should meet on the Monday following. Last year they changed their day from Wednesday back to Tuesday. Our by-laws read: "The regular meeting of the association shall be held annually on the Monday after the second Wednesday in June." Now it should read, "after the second Tuesday in June," or we might have to meet on a different day from what our by-laws require. Therefore, I move that we change the first article of the first by-law to read: "The regular meeting of the association shall be held annually on the Monday after the second Tuesday in June." I might explain that we can change our by-laws at any time, while to change the constitution we would have to give a year's notice.

The motion was carried.

ELECTION OF OFFICERS.

The PRESIDENT—The next business, gentlemen, is the election of officers. You will proceed to ballot for President.

Secretary SINCLAIR—Before the election of officers goes on, I would

like to explain that Mr. Garstang, our 1st Vice-President, is absent, owing to sickness. He wrote to me, wishing that I would explain how warmly he felt toward the interest of the meeting, but sickness and other matters prevented him from being present. I think this is the right time to put that before you.

The PRESIDENT—We will now proceed to the election of President. Mr. Gentry and Mr. Purves will please act as tellers. The election of officers will go on without nomination. No nominations are to be made in the election of officers in this association. They must be elected by ballot separately.

Secretary SINCLAIR—The whole number of votes cast is 67. Mr. Hickey received 51, Mr. Garstang 11, and there were 5 scattering. Mr. Hickey is elected.

Mr. HICKEY—Gentlemen, I desire to thank you for this further mark of respect and confidence. I shall endeavor in the future to do my duty to the association, as I have in the past. I trust that we will all work together, and next year make as good a Convention, at least, as we have this. I shall work certainly for the benefit of the association, and again I thank you. (Applause.) You will prepare your ballots for 1st Vice-President.

Mr. GENTRY—We find in the hat a large number of blank ballots. I suggest that the members who do not vote refrain from throwing into the hat any blank pieces of paper. It only bothers us.

The secretary announced the vote for 1st Vice-President as follows: Mr. Garstang, 55; Mr. Blackall, 5; scattering, 6.

The PRESIDENT—Mr. Garstang is elected 1st Vice-President. You will now proceed to ballot for the 2d Vice-President.

The secretary announced the vote for 2d Vice-President as follows: 65 have voted; 60 for Mr. Blackall and 5 scattering.

The PRESIDENT—Gentlemen, R. C. Blackall is elected 2d Vice-President of this association.

You will next prepare your ballots for Treasurer.

The Convention then proceeded to ballot for Treasurer.

Secretary SINCLAIR—Mr. President, 58 voted; 53 for O. Stewart and 5 scattering.

The PRESIDENT—Gentlemen, I announce that Mr. Stewart is elected Treasurer of this association. We will now proceed to the balloting for Secretary.

The Convention then balloted for Secretary.

Mr. POMEROY—The total number of votes cast is 54, 52 of which are for Mr. Angus Sinclair.

The PRESIDENT—I declare Mr. Angus Sinclair elected Secretary of this association.

WHERE THEY WISH NEXT CONVENTION TO BE HELD.

Before adjourning, I wish to add that it is customary to get an expression from the members as to where they desire to meet the following

ɒusiness life, and the respect and confidence of those who were :mployed under him. He possessed mechanical ability of a high ɒrder, and may be termed an inventive master mechanic, and he vas one of the ablest of this class. As a clear-headed designer ɒf machinery, as a business-like shop superintendent, and as a nanager of men, he had few equals.

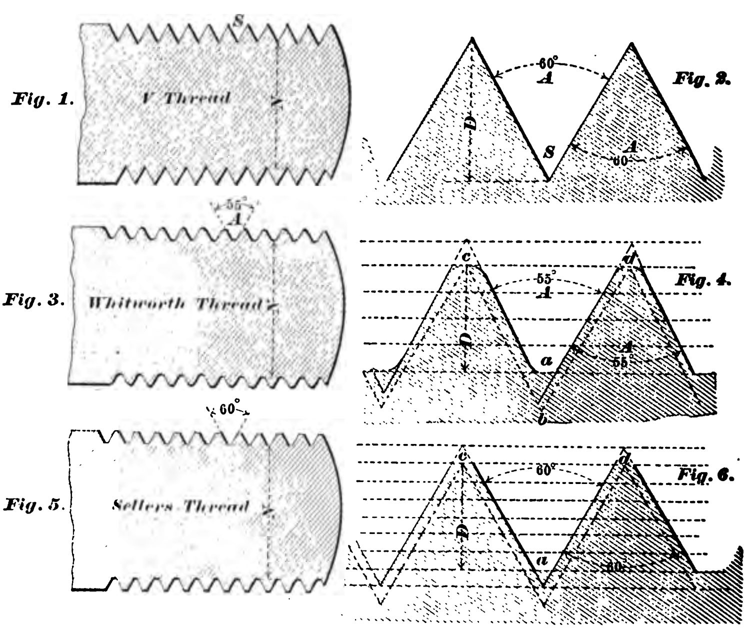
He leaves three daughters to mourn his loss, to whom we ex- :end the sympathy of this association.

A. W. QUACKENBUSH.

STANDARDS ADOPTED BY THE AMERICAN RAILWAY MASTER MECHANICS' ASSOCIATION.

SCREW THREADS.

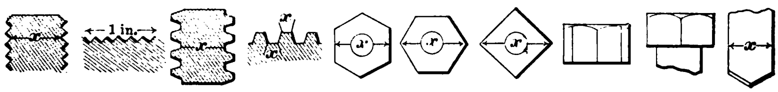
At the Third Annual Convention the report of a committee recommending the United States Standard Screw Thread was adopted. Annexed are the forms and dimensions of the threads in question.



SCREW THREADS. SELLERS' STANDARD.

The association at the Twenty-fifth Annual Convention adopted

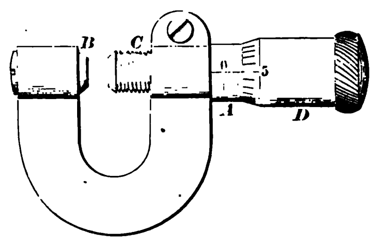
the United States standard sizes of nuts and bolt heads, particulars of which are given below:



Diameter of Screw.	Threads per inch.	Diameter at root of Thread.	Width of flat.	Short diameter of Hexagon or Square.	Long Diameter Hexagon.	Long Diameter Square.	Thickness Nuts.	Thickness Heads.	Tap Drill.
1/4	20	.185	.0062	1/2	37/64	7/10	1/4	1/4	3/16
5/16	18	.240	.0074	19/32	11/16	10/12	5/16	19/64	1/4
3/8	16	.294	.0078	11/16	51/64	63/64	3/8	11/32	5/16
7/16	14	.344	.0089	25/32	9/10	1 7/64	7/16	25/64	23/64
1/2	13	.400	.0096	7/8	1	1 15/64	1/2	7/16	13/32
9/16	12	.454	.0104	31/32	1 1/8	1 23/64	9/16	31/64	15/32
5/8	11	.507	.0113	1 1/16	1 7/32	1 1/2	5/8	17/32	17/32
3/4	10	.620	.0125	1 1/4	1 7/16	1 49/64	3/4	5/8	5/8
7/8	9	.731	.0138	1 7/16	1 21/32	2 1/32	7/8	23/32	3/4
1	8	.837	.0156	1 5/8	1 7/8	2 19/64	1	13/16	27/32
1 1/8	7	.940	.0178	1 13/16	2 3/32	2 9/16	1 1/8	29/32	31/32
1 1/4	7	1.065	.0178	2	2 5/16	2 53/64	1 1/4	1	1 3/32
1 3/8	6	1.160	.0208	2 3/16	2 17/32	3 3/32	1 3/8	1 3/32	1 3/16
1 1/2	6	1.284	.0208	2 3/8	2 3/4	3 23/64	1 1/2	1 3/16	1 9/32
1 5/8	5 1/2	1.389	.0227	2 9/16	2 31/32	3 5/8	1 5/8	1 9/32	1 13/32
1 3/4	5	1.491	.0250	2 3/4	3 3/16	3 57/64	1 3/4	1 3/8	1 1/2
1 7/8	5	1.616	.0250	2 15/16	3 13/32	4 5/32	1 7/8	1 15/32	1 5/8
2	4 1/2	1.712	.0277	3 1/8	3 5/8	4 27/64	2	1 9/16	1 3/4
2 1/4	4 1/2	1.962	.0277	3 1/2	4 1/16	4 61/64	2 1/4	1 3/4	1 31/32
2 1/2	4	2.176	.0312	3 7/8	4 1/2	5 31/64	2 1/2	1 15/16	2 3/16
2 3/4	4	2.426	.0312	4 1/4	4 29/32	6	2 3/4	2 1/8	2 7/16
3	3 1/2	2.629	.0357	4 5/8	5 3/8	6 17/32	3	2 5/16	2 5/8
3 1/4	3 1/2	2.879	.0357	5	5 13/16	7 1/16	3 1/4	2 1/2	2 29/32
3 1/2	3 1/4	3.100	.0384	5 3/8	6 7/64	7 39/64	3 1/2	2 11/16	3 1/32
3 3/4	3	3.317	.0413	5 3/4	6 21/32	8 1/8	3 3/4	2 7/8	3 11/32
4	3	3.567	.0413	6 1/8	7 3/32	8 41/64	4	3 1/16	3 19/32
4 1/4	2 7/8	3.798	.0435	6 1/2	7 9/16	9 3/16	4 1/4	3 1/4	3 13/16
4 1/2	2 3/4	4.028	.0454	6 7/8	7 31/32	9 3/4	4 1/2	3 7/16	4 1/32
4 3/4	2 5/8	4.256	.0476	7 1/4	8 13/32	10 1/4	4 3/4	3 5/8	4 9/32
5	2 1/2	4.480	.0500	7 5/8	8 27/32	10 49/64	5	3 13/16	4 1/2
5 1/4	2 1/2	4.730	.0500	8	9 9/32	11 23/64	5 1/4	4	4 3/4
5 1/2	2 3/8	4.953	.0526	8 3/8	9 23/32	11 7/8	5 1/2	4 3/16	4 31/32
5 3/4	2 3/8	5.203	.0526	8 3/4	10 5/32	12 3/8	5 3/4	4 3/8	5 7/32
6	2 1/4	5.423	.0555	9 1/8	10 19/32	12 15/16	6	4 9/16	5 7/16

SHEET METAL GAUGE.

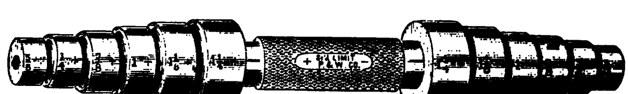
At the Fifteenth Annual Convention the Brown & Sharp micrometer gauge shown below was adopted as standard for the measurement of sheet metal.

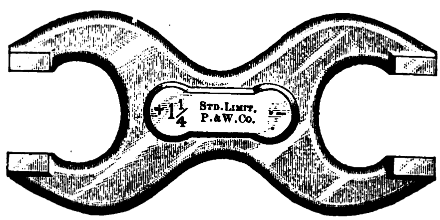


LIMIT GAUGES.

At the Seventeenth Annual Convention the Pratt & Whitney limit gauges for round iron, illustrated on this and following page were adopted. The sizes are as follows :

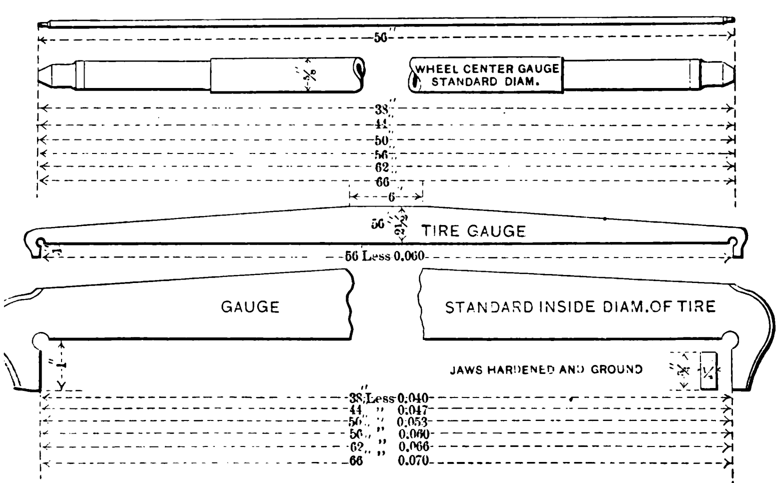
NOMINAL DIAMETER. OF IRON. INCHES.	Large size end. Inches.	Small size end. Inches.	Total variation. Inches.
$\frac{1}{4}$	.2550	.2450	.010
$\frac{5}{16}$	.3180	.3070	.011
$\frac{3}{8}$	.3810	.3690	.012
$\frac{7}{16}$	.4440	.4310	.013
$\frac{1}{2}$	.5070	.4930	.014
$\frac{9}{16}$	.5700	.5550	.015
$\frac{5}{8}$	.6330	.6170	.016
$\frac{3}{4}$	.7585	.7415	.017
$\frac{7}{8}$	.8840	.8660	.018
1	1.0095	.9905	.019
$1\frac{1}{8}$	1.1350	1.1150	.020
$1\frac{1}{4}$	1.2605	1.2395	.021





DRIVING WHEEL CENTERS AND SIZES OF TIRES.

At the Nineteenth Annual Convention the report of a committee was adopted which recommended driving-wheel centers to be made 38, 44, 50, 56, 62 or 66 inches diameter. At the Twentieth Annual Convention the recommendations of a committee were adopted making tire gauges manufactured by Messrs. Pratt & Whitney, Hartford, Conn., and here illustrated, standards of the association. The sizes and the allowance for shrinkage are as follows:



COMMITTEES FOR CONDUCTING THE BUSINESS FOR THE YEAR 1891-2.

No. 1. Exhaust Pipes, Nozzles and Steam Passages.

C. F. THOMAS,
A. W. GIBBS,
S. HIGGINS,
J. M. WALLIS,
GEO. W. SMITH,
ROBERT QUAYLE,
JOHN Y. SMITH.

No. 2. Standard Tests for Locomotives.

To investigate the practicability of establishing a standard system of tests to demonstrate the fuel and water consumption of locomotives. Also to ascertain the value of the steam engine indicated in locomotive tests.

J. N. LAUDER,
W. J. ROBERTSON,
ALBERT GRIGGS,
JOHN D. CAMPBELL,
F. W. DEAN.

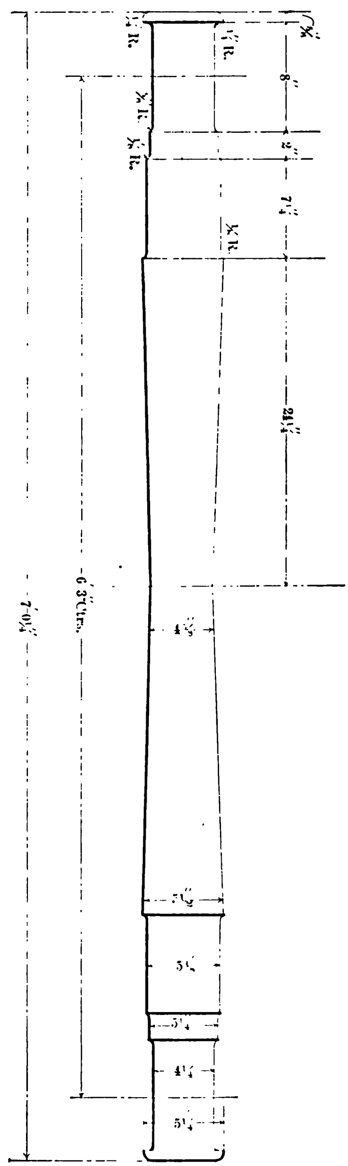
No. 3. Compound Locomotives.

To investigate the relative economy of compound and simple locomotives; also the most valuable form of compound locomotive.

GEORGE GIBBS,
WILLIAM H. LEWIS,
PULASKI LEEDS,
JAMES MEEHAN,
T. W. GENTRY,
A. T. WOODS.

Axle for Heavy Tenders.

The accompanying illustration shows the dimensions of the **axle** for heavy tenders recommended by a committee of the association.



DAVID PRESTON.

The death of Mr. David Preston, the mechanical superintendent of the Canadian Pacific Railway, which occurred at Montreal on the 13th of April, leaves a gap in the ranks of the railroad pioneers of forty years ago. The deceased was of Scotch parentage, and was born near Guthrie, in Forfarshire, on the 23d of May, 1830. He received a good education, and began life in the service of the Scottish Midland & Aberdeen Railway. At the age of twenty-four he came to Canada. After his arrival he was for a short time engaged in the work of building the famous tubular bridge, which carries the tracks of the Grand Trunk Railway over the St. Lawrence at Montreal. He was subsequently employed on the Grand Trunk, running an express engine between Toronto, Belleville and Kingston. His ability and faithful service soon raised him to the position of foreman of the company's shops at Toronto. In 1877 he accepted the post of mechanical superintendent of the Toronto, Grey & Bruce Railway. This road runs from Toronto to the port of Owen Sound, on the Georgian Bay, and was then narrow gauge. At the time Mr. Preston was selected to take charge of the mechanical department, the Toronto, Grey & Bruce Railway Company was contemplating a change of gauge to the standard, 4 ft. 8½ in. Most of the locomotives on that line had been built in Great Britain, and their conversion was by no means an easy task, with the comparatively limited stock of machinery then owned by the company. In 1883 the Canadian Pacific Railway, then only three years in existence, leased the line just built from Toronto to Perth, reaching Montreal via Ottawa by the old Brockville & Ottawa and the Quebec, Montreal, Ottawa & Occidental Railways.

At the same time it acquired the T., G. & B. and the Credit Valley Railways. Mr. Preston was appointed division master mechanic by the Canadian Pacific Railway and given charge of the newly built and acquired lines in Southern Ontario. He was afterwards given charge of the main line from Port Arthur to Montreal, in addition. In the early part of 1890 he was promoted to the position of mechanical superintendent over the whole line, covering upward of 6,000 miles. This position he

held up to the time of his death. Mr. Preston possessed in a great measure the rare faculty of managing and controlling men. The possession of this quality was a fact which largely assisted in his own advancement. Throughout his successful career he was always the firm friend and helper of all younger aspirants to success with whom he came in contact. It can be truly said of him that he achieved his position—passing through the various grades to the highest place in the profession—without trampling on the rights of a single fellow-employé. He died universally regretted by all the officials of the company with whom he had been in contact, and was regarded as one of the kindest-hearted men that ever occupied such a position.

R. Atkinson.

ISAAC DRIPPS.

The little circle of charter members of this association was narrowed down again by the death of Isaac Dripps on December 28, 1892.

Mr. Dripps was born in Belfast, Ireland, April 17, 1810, and came to this country with his parents when a mere child.

At sixteen years of age he became an apprentice to Thomas Holloway, of Philadelphia, who then had one of the largest machine shops in that city and made a specialty of marine work. Mr. Dripps became a foreman before he was twenty years old, and was in charge of extensive repairs to the steamer *Swan* in New York harbor when he became of age.

He resigned at this time and entered the employ of Robert L. Stevens, president of the Camden & Amboy Railroad, and received, set up, and ran the famous locomotive "John Bull."

He now took charge of the company's shops at Hoboken and built seven locomotives, and got them into service at South Amboy—men had to be taught to handle them—by the time the company were ready to transport passengers by steam. This was in the fall of 1833. At this time Mr. Dripps was made superintendent of machinery, and he was the first man to hold that title in America. He had charge of all the floating equipment, as well as the railroad machinery.

Mr. Dripps designed the large stack with inside pipe and cone, he put the first deflector-plate in a smoke-arch, invented the combustion chamber—using two sets of flues—and put in the first high, single nozzle, all before the close of 1834.

To Isaac Dripps belongs the credit of making the first single screw propeller; he had charge of the steam propeller "Commodore Stockton," afterwards renamed the "New Jersey," built in England by Capt. John Ericsson in 1839. This boat had two screws, revolving in opposite directions to prevent listing of the boat—they were unsatisfactory, the engines complicated, and the hollow shaft troublesome. In 1840 Mr. Dripps overhauled the boat, put in a simple engine and built a six-bladed single screw that was a success from the start, and ran the boat for more than a quarter of a century. From 1853 to 1857, Mr. Dripps was superintendent and part owner of the

No. 11. Tender Frames.

Report on best form of tender and truck frames of wood and iron.

R. C. BLACKALL, E. E. DAVIS,
JOHN MACKENZIE, T. PURVES, JR.,
F. B. MILES.

Obituary Notices.

SUBJECT.	COMMITTEE.
ROSS KELLS,	LEROY KELLS,
WM. F. TURREFF	WM. FULLER,
JOSEPH BRADT	A. DOLBEER,
S. D. BRADLEY	J. E. KEEGAN,
EDWARD NICHOLS	M. L. HINMAN,
WM. SMITH,	E. E. DAVIS,
WM. WILSON	A. QUACKENBUSH,
O. A. HAYNES	H. ELLIOT,
JAMES SEDGLEY	G. A. STEVENS.

On Applications for Associate Membership.

	COMMITTEES.
GEORGE H. BAKER,	J. N. LAUDER, WM. SWANSTON, R. H. BRIGGS.
JOHN H. LEEDS,	O. STEWART, J. D. CAMPBELL, F. M. TWOMBLY.
H. P. ROBINSON,	J. N. BARR, G. F. WILSON, PETER H. PECK.

Committee on Subjects for Investigation.

GEORGE GIBBS, WILLIAM SMITH,
E. M. ROBERTS.

Delegates to American Society of Railroad Superintendents' Convention.

J. N. LAUDER,
JOHN MACKENZIE.

Executive Committee.

JOHN HICKEY, R. C. BLACKALL,
WILLIAM GARSTANG, O. STEWART,
ANGUS SINCLAIR.

NAMES AND ADDRESSES OF MEMBERS.

JOINED.	NAME.	ROAD.	ADDRESS.
1888..	Addis, J. W....	Texas & Pacific........	Gouldsboro, Ia.
1890..	Agnew, J. H...........	....	Allegheny, Pa.
1887..	Aldcorn, Thos.......	West Shore............	New Durham, N. J.
1892..	Allen. G. S..........	Phil. & Reading.......	Tamaqua, Pa.
1886..	Ames, L.	Beech Creek...	Jersey Shore, Pa.
1892..	Antz, Oscar....................	56	Taylor st., Newark, N. J.
1887..	Arp, W. C...........	P. C. C. & St. L.......	Dennison, O.
1890..	Atkinson, R..........	Canadian Pacific.......	Montreal, Que.
1887..	Augustine, W........	Keokuk & Western....	Centerville, Ia.
1886..	Austin, W. L.............	Baldwin Loco. Works,	Philadelphia, Pa.
1889..	Ball, A. W...........	N. Y. L. E. & W.......	Galion, O.
1892..	Ball, A. J....	....C. S. & Hocking... ..	Columbus, O.
1888..	Barnes, J. B....	Wabash...	Springfield, Ill.
1892..	Barnett, A. R	Boston & Maine.......	Boston, Mass.
1877..	Barnett, J. Davis.....	Grand Trunk..........	Stratford, Ont.
1886..	Barnett, T. E.......	Canadian Pacific.......	Vancouver, B. C.
1890..	Barr, J. N...........	C. M. & St. P..........	Milwaukee, Wis.
1890..	Barnum, M. K.......	Union Pacific..........	North Platte, Neb.
1889..	Battye, John E.. ..	N. & W...............	Shenandoah, Va.
1885..	Bean, John...	C. & Canton...........	Canton, O.
1889..	Bean, S. L...........	Northern Pacific.......	Fargo, N. Dak.
1892..	Beattie, A. L........	New Zealand Gov't....	Wellington, N. Z.
1885..	Beckert, Andrew....	Louis. & Nashville.....	Decatur, Ala.
1892..	Benson, A. E........	Ulster & Delaware.....	Rondout, N. Y.
1891	Berry, J. H	C. C. C. & St. L.......	Delaware, O.
1892..	Billingham, Jos.	Gulf, Col. & S. F.. ...	Galveston, Tex.
1879..	Bissett, John...	W. W. C. & A.........	Wilmington, N. C.
1872..	Blackall, R. C.......	D. & H. Canal Co.....	Albany, N. Y.
1883..	Blackwell, Charles....	Mount Look-out.......	Cincinnati, O.
1887..	Boatman, F. P.......	C. N. O. & T. P........	Ludlow, Ky.
1869..	Boon, J. M..........	West Shore...........	Frankford, N. Y.
1890..	Boyle, Wilson L......	N. Y. C. & H. R......	West Albany, N. Y.
1890..	Bradford, J. C.......	Rhode Island Loco. Works,	Providence, R. I.

JOINED.	NAME.	ROAD.	ADDRESS.
1888	Bradley, W. F.	K. & Michigan	Charleston, W. Va.
1870	Brastow, L. C.	Central of N. Jersey	Ashley, Pa.
1879	Briggs, R. H.	K. M. C. & B	Memphis, Tenn.
1887	Brooke, Geo. B.	St. Paul & Duluth	St. Paul, Minn.
1890	Brown, Angus	Northern Pacific	Livingston, Mont.
1892	Brown, David	D. L. & W.	Scranton, Pa.
1887	Brown, F. R. F.		Toronto, Ont.
1891	Brown, J. L.	Pitts. & Western	Allegheny, Pa.
1891	Brown, W. A.	Atlantic & Danville	Portsmouth, Va.
1882	Brownell, F. G.		Muncie st., Muncie, Ind.
1891	Bruce, Frank	Great Northern	Barnesville, Minn.
1890	Bruck, Henry T	C. & Penn.	Mt. Savage, Md.
1882	Bryan, H. S.	D. & I. Range	Two Harbors, Minn.
1890	Bryant, J. T.	Rich. Fred. & Potomac	Richmond, Va.
1887	Buchanan, Wm	N. Y. C. & H. R.	New York, N. Y.
1891	Burns, C. H.	Hous. & Tex. Central	Houston, Tex.
1870	Bushnell, R. W.	B. C. R. & N.	Cedar Rapids, Ia.
1891	Butler, L. M.	N. Y., Prov. & Boston	Providence, R. I.
1890	Butterly, T. E.	Wabash	Moberly, Mo.
1883	Campbell, John	Lehigh Valley	Delano, Pa.
1891	Campbell, John D.	N. Y. Central	West Albany, N. Y.
1889	Carmody, T.	N. Y. P. & O.	Cleveland, O.
1885	Carson, M. T.	Mobile & Ohio	Jackson, Tenn.
1889	Casanave, F. D.	P. Ft. W. & C	Ft. Wayne, Ind.
1890	Casey, J. J.	L. N. O. & Tex.	Vicksburg, Miss.
1868	Chapman, N. E.		251 S. 4th st., Philadelphia, Pa.
1878	Chapman, T. L.		46 W. 93d st., New York, N. Y.
1870	Clark, David	Lehigh Valley	Hazelton, Pa.
1886	Clark, Isaac W.	C. F. & Y. V.	Fayetteville, N. C.
1877	Clifford, J. G.	L. & Nashville	Mobile, Ala.
1887	Cloud, John W.		Rookery Building, Chicago, Ill.
1891	Cockfield, Wm	Mexican Central	Jimulco, Mex.
1885	Collier, M. L.	Western & Atlantic	Atlantic, Ga.
1891	Collinson, James	Atch., Topeka & S. F.	Fort Madison, Ia.
1890	Conolly, J. J.	D. S. S. & A	Marquette, Mich.
1892	Cooley, M. W.	Southern Pacific	Fresno, Cal.
1890	Cooper, Chas. J	Toledo, Col. & Cin.	Kenton, O.
1879	Cook, John S.	Georgia	Augusta, Ga.
1879	Cooke, Allen		Danville, Ill.
1891	Cooke, W. J.	Ch. & W. Mich.	Muskegon, Mich.
1888	Cory, C. H.	C. H. & D.	Lima, O.
1892	Crawford, S. B.	Balt. & Ohio	Mt. Clare, Balt., Md.
1885	Cromwell, A. J.	Balt. & Ohio	Baltimore, Md.
1883	Cullen, James	N. C. & St. L.	Nashville, Tenn.

JOINED.	NAME.	ROAD.	ADDRESS.
1889	Curran, Peter	N. Y. L. E. & W.	Bradford, Pa.
1872	Cushing G. W		Am. Steel Wheel Co., Boston, Mass.
1892	Dailey, J. B.	Rio Grande Western	Salt Lake City, Utah.
1888	Dallas, Wilber C		947 Desoto Street, St. Paul, Minn.
1890	Davies, J. M.	Chateaugay	Lyon Mt., N. Y.
1892	Davis, Ed. E	Boston & Maine	Boston, Mass.
1886	Davis, Jas. A	N. T. & Q.	Deseronto, Ont.
1891	Deems, J. F	C. Bur. & Quin	Ottumwa, Ia.
1892	Dehn, F. H	Texas Central	Walnut, Tex.
1889	Deibert, F. W	Ch., M. & St. P	Portage, Wis.
1892	Derby, Abram	South Florida	Sanford, Fla.
1890	Derby, R	South Florida	Sanford, Fla.
1887	Dickson, G. L		Dickson Loco. Works, Scranton, Pa.
1887	Dickson, J. P		Dickson Loco. Works, Scranton, Pa.
1890	Dolbeer, Alonza	B. R. & Pittsburgh	Rochester, N. Y.
1882	Domville, C. K.	Grand Trunk	Hamilton, Ont.
1892	Dorsey, J. B	Ohio River	Parkersburg, W. Va.
1883	Downe, George	Government	Sidney, N. S. W.
1890	Downing, T	El. Jol. & Eastern	Joliet, Ill.
1889	Durrell, D. J	Illinois Central	Chicago, Ill.
1881	Eastman, A. G		Sutton, Que.
1868	Eddy, W. H	Boston & Albany	Springfield, Mass.
1869	Elliott, Henry		East St. Louis, Ill.
1883	Ellis, Matt	C. St. P., M. & O.	St. Paul, Minn.
1881	Ennis, W. C	N. Y. S. & W.	Wortendyke, N. J.
1892	Esson, R. C	Southern Pacific	Newark, Cal.
1886	Ettinger, G. T		New York, N. Y.
1883	Evans, Edward	Balt. O. &. S. Western	Chillicothe, O.
1885	Fenwick, A	G. B. W. & St. Paul	Green Bay, Wis.
1885	Ferguson, G. A	Concord & Montreal	Lake Village, N. H.
1889	Ferry, F. J.	Louis., St. Louis & Tex.	Cloverport, Ky.
1874	Finlay, L		902 West 4th Street, Little Rock, Ark.
1886	Flahaven, W. M	P. & W.	Allegheny, Pa.
1888	Forsyth, Wm	C. B. & Q.	Aurora, Ill.
1875	Foster, W. A		Fall Brook Coal Co., Corning, N. Y.
1890	Foulks, John	T. St. L. & K. C.	Charleston, Ill.
1877	Fowle, I. W	Colorado Midland	Leadville, Col.
1887	Fraser, T. A		Wells & French Car Works, Chicago, Ill.
1891	French, R. E	Southern Pacific	Oakland, Cal.
1890	Fuller, C. E	N. Y. L. E. & W.	Jersey City, N. J.
1872	Fuller, Wm		213 Kennard Street, Cleveland, O.

JOINED.	NAME.	ROAD.	ADDRESS.
1891	Galbraith, R. M	St. L. A. & Tex	Tyler, Tex.
1885	Galloway, A.	T. A. A. & N. H	Owosso, Mich.
1890	Garlock, W. H	S. L. S. & E	Seattle, Wash.
1883	Garrett, H. D	Pennsylvania	Philadelpia, Pa.
1892	Garrison, C. E	West Shore	E. Buffalo, N. Y.
1887	Garstang, Wm	Ches. & Ohio	Richmond, Va.
1886	Gentry, T. W	Richmond & Danville	Richmond, Va.
1883	George, Nathan M		Danbury, Conn.
1890	Gessler, Wm	C. R. I. & P	Trenton, Mo.
1888	Gibbs, A. W	Richmond & Danville	Atlanta, Ga.
1890	Gibbs, George	C. M. & St. Paul	Milwaukee, Wis.
1892	Giles, C. F.	L. & Nashville	Pensacola, Fla.
1891	Gillis, H. A	N. Y. L. E. & W	Port Jervis, N. Y.
1883	Gilmore, W. L	L. S. & M. S	Elkhart, Ind.
1890	Givan, F. A	Norfolk & Western	Norfolk, Va.
1891	Glass, Jno. B.	Allegheny Valley	Verona, Pa.
1891	Gleasier, T. W	Mexican Central	Silao, Mex.
1891	Glover, J. B	Marietta & Nor. Ga	Marietta, Ga.
1880	Gordon, H. D		Juniata Shops, Altoona, Pa.
1879	Gordon, Jas. T	Concord	Concord, N. H.
1891	Gould, Amos	N. Y. C. & H. R	E. Buffalo, N. Y.
1869	Graham, Chas	D. L. & Western	Scranton, Pa.
1892	Graham, Chas. Jr	D. L. & Western	Kingston, Pa.
1882	Graham, J. S	L. S. & M. S	Cleveland, O.
1892	Gray, Robert W	Southern Pacific	Tucson, Ariz.
1889	Greatsinger, J. L.	D. & I Range	Two Harbors, Minn.
1892	Green, Jos. H	R. & Danville	Columbia, S. C.
1891	Griffin, B. F	D. & I Range	Two Harbors, Minn.
1885	Griffith, Fred. B	D. L. & Western	Buffalo, N. Y.
1872	Griggs, Albert		15 Wayland Street, Dorchester, Mass.
1887	Gugel, Daniel M		Macon, Ga.
1880	Hackney, Clem		624 Washington Street, Milwaukee, Wis.
1880	Hackney, George		Chicago, Ill.
1875	Haggett, J. C	D. & A. Valley	Dunkirk, N. Y.
1886	Haggerty, G. A	Canadian Pacific	McAdams Junct., N. B.
1889	Hall, Don Diego	Government Railways	Santiago, Chili.
1883	Hall, J. N		Montgomery, Ala.
1890	Haller, W. J	Ches. & Ohio	Covington, Ky.
1870	Ham, C. T.	Buffalo Steam Gauge Co.	Rochester, N. Y.
1891	Hancock, Geo. A	S. A. & A. P	San Antonio, Tex.
1875	Harding, B. R	R. G. R. & A	Raleigh, N. C.
1888	Harrington, John	Mexican Northern	Escalon, Mex.
1888	Harris, Geo. D	Georgia Southern	Macon, Ga.
1885	Harrison, W. H	Baltimore & Ohio	Newark, O.

E. J. WHITTINGTON.

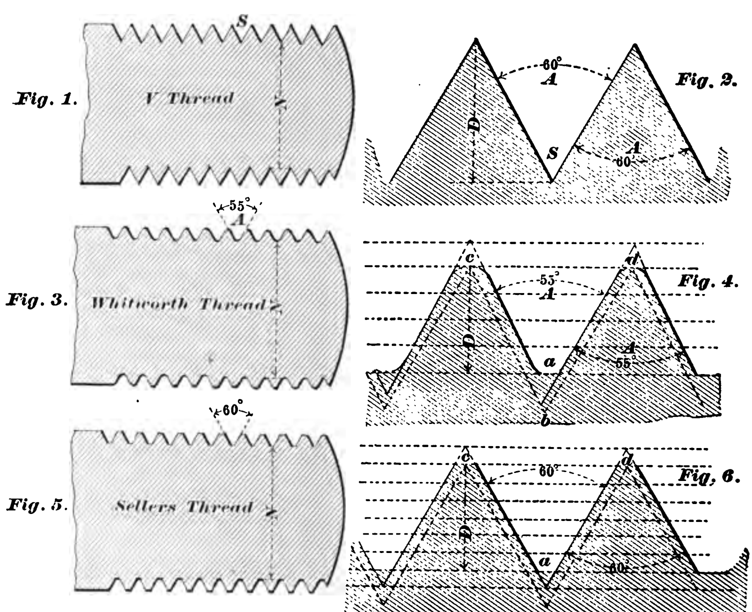
E. J. Whittington was born November 1, 1854, at Fayette, Howard county, Mo. He commenced work as an apprentice in the Wabash shops at Moberly, Mo., in 1874; continued in the employ of this company until 1882. He then went to Missouri Pacific Railway at Sedalia, Mo., as a machinist and continued in the service of this company three years. From there he went to the Atchison, Topeka & Santa Fé and was in their employ two years, then returned to Moberly as roundhouse foreman; continued in this capacity for about two years. In August, 1889, left Moberly to accept situation as division master mechanic at Slater, Mo., on the Chicago & Alton Railroad, in which position he continued until his death, which occurred March 20, 1892. He joined the association in 1890. Mr. Whittington leaves a wife and five children, who have the sympathy of this association.

ANGUS SINCLAIR,
Committee.

Standards Adopted by the American Railway Master Mechanics' Association.

Screw Threads.

At the Third Annual Convention the report of a Committee recommending the United States standard screw thread was adopted. Annexed are the forms and dimensions of the threads in question.

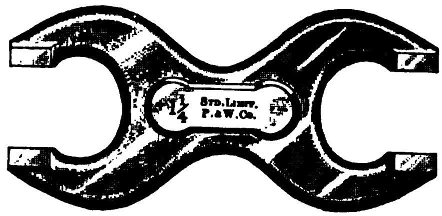


Screw Threads. Sellers' Standard.

The association at the Twenty-fifth Annual Convention adopted

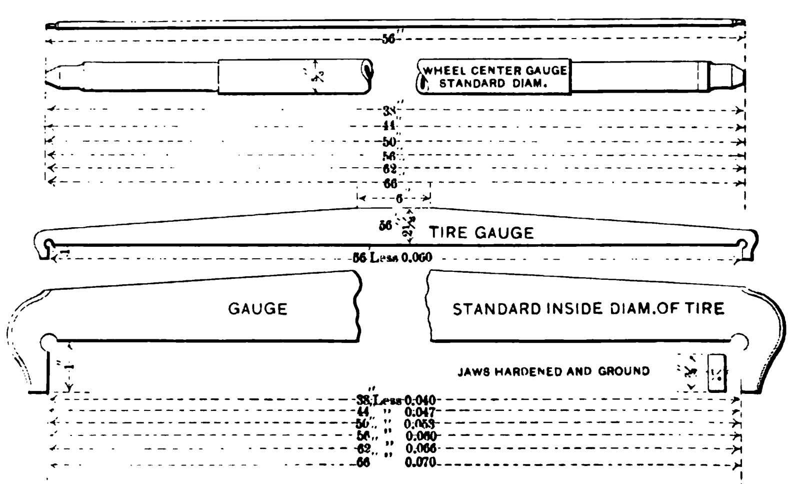
JOINED.	NAME.	ROAD.	ADDRESS.
1891	Manuell, Geo.	Mobile & Ohio.	Jackson, Tenn.
1890	Marshall, E. S.		Madison Car Works, Madison, Ill.
1888	Mayer, A. A.	Grand Trunk	Stratford, Ont.
1889	May, Edward	Intercolonial	Moncton, N. B.
1892	McCann, Thos	Georges Creek & Cum.	Cumberland, Md.
1892	McCarthy, J. C.	N. O. & N. E.	Meridian, Miss.
1891	McClurg, John	C. C. C. & St. L	Urbana, Ill.
1891	McConnell, J. H.	Union Pacific.	Omaha, Neb.
1890	McCormick, J. H.	C. & P. Sound.	Seattle, Wash.
1890	McCreery, Frank.	C. H. & Dayton.	Dayton, O.
1875	McCrum, J. S.	K. C. Ft. S. & G	Kansas City, Mo.
1892	McCuen, J. P	V. S. & P.	Monroe, La.
1892	McGee, F. H.	Central of Georgia	Macon, Ga.
1883	McGrayel, John		Grand Junction, Ia.
1892	McDuff, Allan.	B. C. R. & N	Cedar Rapids, Ia.
1892	McIlwain, J. D.		Harvey Steel Car Works, Chicago. Ill.
1890	McIntosh, Wm	Ch. & Northwestern	Winona, Minn.
1891	McKenna, John.	I. D. S.	Indianapolis. Ind.
1890	McNaughton, Jas.	Wis. Central	Waukesha, Wis.
1888	McNiven, P. C		Canadian Loco. Works, Kingston, Ont.
1888	Medway, John	Fitchburg	Mechanicsville, N. Y.
1883	Meehan, James.	C. N. O. & T. P.	Ludlow, Ky.
1892	Mertsheimer, F.	Union Pacific.	Cheyenne, Wyoming.
1887	Michael, J. B.	E. T. V. & Ga.	Knoxville, Tenn.
1883	Middleton, Harvey		Pullman Shops, Pullman, Ill.
1889	Midelton, Thomas	Government Railways.	Sydney, N. S. W.
1885	Millen, Thomas	New York City & N.	High Bridge, N. Y.
1889	Miller, E. A.	Ch. & E. Ill.	Danville, Ill.
1890	Miller, Geo. A.	J. T. & K. W	Palatka, Fla.
1891	Miller, W. H.	C. H. V. & T	Columbus, O.
1890	Mills, Stott.	Lehigh & Hudson	Warwick, N. Y.
1881	Minshull, E.	N. Y. O. & W.	Middletown, N. Y.
1892	Minto, H. M.	L. & Nashville	Mobile, Ala.
1888	Minton, A. B	Mobile & Ohio.	Murphysboro, Ill.
1870	Mitchell, A.	Lehigh Valley.	Wilkesbarre, Pa.
1892	Mitchell, A. E	N. Y. L. E. & West.	New York, N. Y.
1890	Monkhouse, H.	C. R. I. & P.	Horton, Kan.
1888	Montgomery, Wm.	Central of New Jersey.	Manchester, N. J.
1890	Moore, J. H.	N. Y. P. & O.	Meadville, Pa.
1882	Morrell, J. E.	C. R. I. & P.	Davenport, Ia.
1887	Morris, W. S.	C. & W. Mich	Grand Rapids, Mich.
1890	Morse, F. W	Wabash	Ft. Wayne, Ind.
1876	Morse, G. F.		Portland Loco. Works, Portland, Me.
1890	Morse, W. M.	T. & O. C. E.	Marietta, O.
1891	Mott, D. G.	Panama	Colon, Colombia.

JOINED.	NAME.	ROAD.	ADDRESS.
1870	Shaver, D. O	Pennsylvania	Pittsburgh, Pa.
1890	Sheahan, J. F.	Orange Belt	Oakland, Fla.
1891	Sheer, Jas. M	Ohio & Miss.	Washington, Ind.
1890	Sheerer, E. P	Des Moines Union	Des Moines, Ia.
1890	Shields, J. C	Mineral Range	Hancock, Mich.
1890	Silvius, E. T	J. St. A. & H. R	S. Augustine, Fla.
1883	Sinclair, Angus		912 Temple Court, New York, N. Y.
1880	Sitton, B. J	Mid. Belt	Middlesborough, Ky.
1889	Skinner, H. M. C		N. Y. Loco. Works, Rome, N. Y.
1889	Small, H. J	Southern Pacific	Sacramento, Cal.
1887	Small, W. T		St. Paul, Minn.
1886	Smart, C. E	Michigan Central	Jackson, Mich.
1883	Smith, Allison D	Government	New Port, Victoria.
1887	Smith, F. C		Delaware, O.
1890	Smith, Geo. W	A. T. & S. F	Topeka, Kan.
1883	Smith, Howard M		Alexandria, Va.
1892	Smith, John L	N. Y. L. E. & W	Bradford, Pa.
1891	Smith Wm.	Ch. & Northwestern	Chicago, Ill.
1869	Smith, W. T	N. News & Miss. Val.	Lexington, Ky.
1891	Soule, R. H	Norfolk & Western	Roanoke, Va.
1868	Sprague, H. N		Porter Loco. Works, Pittsburgh, Pa.
1886	Stapf, F. M		Mt. Carmel, Ill.
1890	Stamelen, F.	Erie & Huron	Chatham, Ont.
1872	Stearns, W. H	Conn River	Springfield, Mass.
1887	Stephens, S. A		Rhode Island Loco. Works, Providence, R.I.
1874	Stevens, Geo. W	L. S. & M. S.	Cleveland, O.
1892	Stewart, Andrew F.	Ches. & Ohio	Huntington, W. Va.
1885	Stewart. O	Fitchburg	Charlestown, Mass.
1890	Stillman, H	S. D. & S. Pacific	Dunsmuir, Cal.
1885	Stinard, F. A		143 Park ave, Paterson, N. J.
1883	Stokes, J, W	St. L. & Terre Haute	E. St. L., Ill.
1887	Stone, W. A.	L. E. & St. L	Huntingburg, Ind.
1890	Stout, Henry K	Pennsylvania	Sunbury, Pa.
1875	Strode, James	N. Central	Elmira, N. Y.
1891	Strom, L	Sonora	Guyamas, Mex.
1890	Studer, A. L	C. R. I. &. P. S	Stuart, Ia.
1883	Sullivan, A. W	Illinois Central	Chicago, Ill.
1891	Sullivan, J. J	Louisville Southern	Harrodsburg, Ky.
1891	Summerskill. T. A.	Manitoba & N West	Portage la Prairie, Man.
1892	Sumner, Eben T	Boston & Maine	Boston, Mass.
1892	Sutherland. R. D.	Bost., R. Beach & Lynn.	Boston, Mass.
1868	Swanston, Wm	C. St. L. & P	Indianapolis, Ind.
1883	Tandy, H		Brooks Loco. Works, Dunkirk, N. Y.
1883	Teal, S. A	F. E. & M. V	Missouri Val., Ia.



Driving-Wheel Centers and Sizes of Tires.

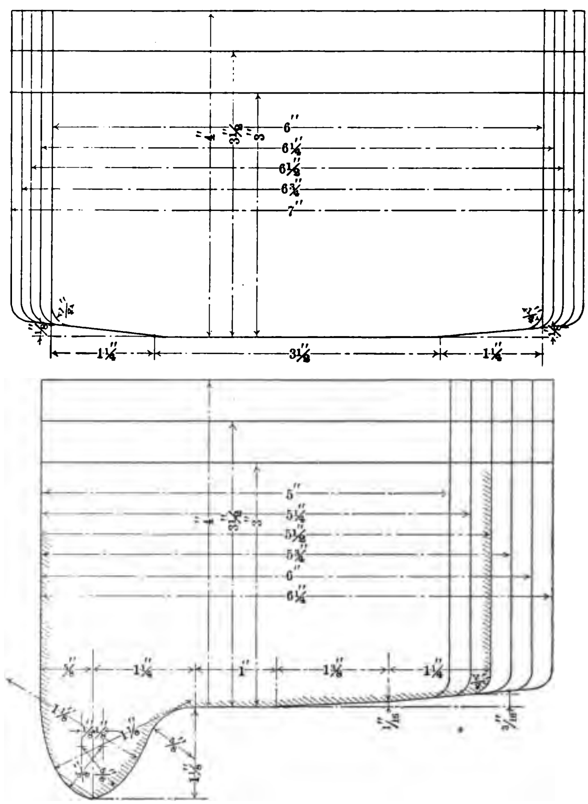
At the Nineteenth Annual Convention the report of a Committee was adopted which recommended driving-wheel centers to be made 38, 44, 50, 56, 62 or 66 inches diameter. At the Twentieth Annual Convention the recommendations of a Committee were adopted making tire gauges manufactured by Messrs. Pratt & Whitney, Hartford, Conn., and here illustrated, standards of the association. The sizes and the allowance for shrinkage are as follows:



At the Twenty-sixth Annual Convention the following sizes were adopted as standard for large driving-wheels: 70, 74, 78, 82, 86 and 90 inches.

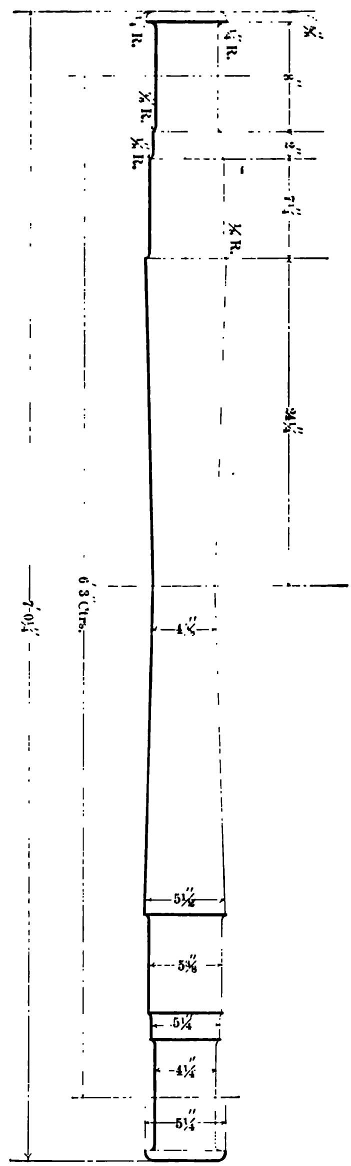
Standard Forms of Tires.

At the Twenty-sixth Annual Convention the forms of tires shown in the annexed engraving were adopted as standard. Railroad companies ordering tires will save time by specifying these forms.



Axle for Heavy Tenders.

The accompanying illustration shows the dimensions of the axle for heavy tenders recommended by a Committee of the association.



Committees for Conducting the Business

FOR THE

YEARS 1893-94.

No. 1. Cracking of Back Tube Sheets.

What method of construction can be devised to prevent the cracking of tube sheets?

T. B. PURVES,
J. M. BOON,
R. C. BLACKALL,
DAVID BROWN,
JOHN MACKENZIE,
L. R. POMEROY.

No. 2. Oiling Devices for Long Runs.

What devices can be provided for locomotives to supply lubrication on long runs?

J. DAVIS BARNETT,
JOHN D. CAMPBELL,
GEO. W. STEVENS,
GEO. W. WEST,
C. E. SMART,
W. D. CROSMAN.

No. 3. Locomotive Fire Kindlers.

Best methods of starting fires in locomotives and their relation to insurance risks.

JOHN HICKEY,
A. PATTEE,
GEO. B. BROOKE,
W. MCINTOSH,
W. T. REED,
JOHN A. HILL.

No. 4. Exhaust Nozzles and Steam Passages.

Robert Quayle,
Wm. Forsyth,
James McNaughton,
Jas. W. Hill,
W. S. Morris,
D. L. Barnes.

No. 5. Boiler and Firebox Steel.

To report on standard specifications and tests for boiler and firebox steel for adoption by the association.

A. W. Gibbs,
G. R. Henderson,
J. A. Lawes,
Wm. Forsyth,
E. M. Roberts,
W. D. Crosman.

No. 6. Sanding Devices.

O. Stewart,
F. M. Twombly,
L. M. Butler,
C. E. Fuller,
John Medway,
H. P. Robinson.

No. 7. Special Shop Tools.

To report on new or improved appliances, either hand, power, pneumatic, hydraulic or electric, applied or applicable to locomotive manufacture and repair.

T. W. Gentry,
Geo. L. Potter,
H. D. Gordon,
G. R. Joughins,
Wm. Swanston,
F. B. Miles.

No. 8. Standard Tests of Locomotives.

(Continued from last year.)

J. N. LAUDER,
GEO. GIBBS,
P. LEEDS,
R. H. SOULE,
ANGUS SINCLAIR,
F. W. DEAN.

No. 9. Tire Treatment.

What is the amount of shrinkage to be allowed for large driving-wheels? Is there any necessity for retaining rings or clips? What is the limit of thickness tires should be worn down to? What is the greatest permissible depth of groove on tire-tread before turning?

A. E. MITCHELL,
G. W. WEST,
THOS. MILLEN,
J. H. MCCONNELL,
A. J. CROMWELL,
JOHN Y. SMITH.

No. 10. Cost of Maintaining Locomotives.

Report on the comparative cost for repairs of locomotives built in contract shops and those built in railroad shops.

G. W. RHODES,
JACOB JOHANN,
W. SMITH,
J. N. BARR,
WM. GARSTANG,
W. H. MARSHALL.

Obituary Notices.

SUBJECT.	COMMITTEE.
N. E. CHAPMAN......	L. R. POMEROY, J. N. LAUDER, GEO. W. STEVENS.
JOSEPH S. PORTER..	WM. SWANSTON, WM. GARSTANG.

Obituary Notices—continued.

SUBJECT.	COMMITTEE.
H. L. LEACH	H. L. LEACH, JR., GEO. RICHARDS, JOHN THOMPSON.
DAVID PRESTON	R. ATKINSON.
ISAAC DRIPPS	JOHN A. HILL, R. WELLS, F. D. CASANAVE.
A. T. WOODS	D. A. BARNES, GEO. GIBBS, WM. FORSYTH.
CHARLES R. PEDDLE	G. H. PRESCOTT.
JOHN BLACK	C. H. CORY.
L. C. BRASTON	W. MONTGOMERY.
E. J. WHITTINGTON	ANGUS SINCLAIR.
BASIL MANLEY	B. R. HARDING.
S. W. WAKEFIELD	A. L. STUDER.
MATT. ELLIS	JOHN J. ELLIS.
JOHN ORTTON	W. I. COOKE.

Several committees failed to send in notices.

Application for Associate Membership.

	COMMITTEE.
WILLIS C. SQUIRE	W. MCINTOSH, W. H. LEWIS, WM. FORSYTH.

Committee on Subjects for Investigation.

GEO. GIBBS, WM. SMITH,
J. DAVIS BARNETT.

Delegates to American Society of Railway Superintendents' Convention.

J. N. LAUDER,
JOHN MACKENZIE.

Executive Committee.

JOHN HICKEY, R. C. BLACKALL,
WM. GARSTANG, O. STEWART,
ANGUS SINCLAIR.

Names and Addresses of Members.

JOINED.	NAME.	ROAD.	ADDRESS.
1888	Addis, J. W	Texas & Pacific	Gouldsboro, La.
1890	Agnew, J. H		114 North Main st., Findlay, O.
1887	Aldcorn, Thos		New Durham, N. J.
1892	Allen, G. S	Phil. & Reading	Tamaqua, Pa.
1886	Ames, L.	Beech Creek	Jersey Shore, Pa.
1892	Anderson, J. J	Central of Georgia	Savannah, Ga.
1892	Antz, Oscar	L. S. & M. S	Cleveland, O.
1887	Arp, W. C	P. C. C. & St. L	Dennison, O.
1890	Atkinson, R	Canadian Pacific	Montreal, Que.
1887	Augustus, W	Keokuk & Western	Centerville, Ia.
1886	Austin, W. L	Baldwin Loco. Works	Philadelphia, Pa.
1889	Ball, A. W	N. Y. L. E. & W	Galion, O.
1892	Ball, A. J	C. S. & Hocking	Columbus, O.
1888	Barnes, J. B	Wabash	Springfield, Ill.
1892	Barnett, A. R	B. & M	Boston, Mass.
1877	Barnett, J. Davis	Grand Trunk	Stratford, Ont.
1886	Barnett, T. E	Canadian Pacific	Vancouver, B. C.
1890	Barr, J. N	C. M. & St. P	Milwaukee, Wis.
1890	Barnum, M. K	Union Pacific	North Platte, Neb.
1889	Battye, John E	N. & W.	Shenandoah, Va.
1885	Bean, John	C. & Canton	Canton, O.
1889	Bean, S. L.	Northern Pacific	Fargo, N. Dak.
1892	Beattie, A. L	New Zealand Govern.	Wellington, N. Z.
1892	Bechhold, H. G	Clev. Frog & Crossing Co.	Cleveland, O.
1885	Beckert, Andrew	L. & Nashville	Decatur, Ala.
1892	Beltz, A. J	Del., Sus. & Schuylkill	Drifton, Pa.
1892	Benson, A. E	Ulster & Delaware	Rondout, N. Y.
1891	Berry, J. H	C. C. C. & St. L	Delaware, O.
1892	Billingham, Jos		Conemaugh, Pa.
1879	Bisset, John	W. W. C. & A	Wilmington, N. C.
1872	Blackall, R. C	D. & H. Canal Co	Albany, N. Y.
1883	Blackwell, Chas	Mount Lookout	Cincinnati, O.
1887	Boatman, F. P		

JOINED.	NAME.	ROAD.	ADDRESS.
1893	Bond, I	N. Y., L. E. & W	Hornellsville, N. Y.
1869	Boon, J. M	West Shore	Frankfort, N. Y.
1890	Boyle, Wilson L	W. Albany Mach. Shops	West Albany, N. Y.
1890	Bradford, J. C	R. I. Loco. Works	Providence, R. I.
1888	Bradley, W. F	T. A. A. & N. M	Owosso, Mich.
1892	Brehn, W. H	M. K. & T	Parsons, Tex.
1879	Briggs, R. H	K. M. C. & B	Memphis, Tenn.
1887	Brooke, Geo. B	St. P. & Duluth	St. Paul, Minn.
1890	Brown, Angus	Northern Pacific	Livingston, Mont.
1892	Brown, David	D. L. & W	Scranton, Pa.
1887	Brown, F. R. F	Intercolonial Ry	Moncton, N. B.
1891	Brown, J. L	P. & Western	Allegheny, Pa.
1891	Brown, W. A	A. & Danville	Portsmouth, Va.
1882	Brownell, F. G		Muncie st., Muncie, Ind.
1891	Bruce, Frank	Mont. Central	Great Falls, Mont.
1890	Bruck, Henry T	C. & Penn	Mt. Savage, Md.
1882	Bryan, H. S	D. & I. Range	Two Harbors, Minn.
1890	Bryant, J. T	R., F. & P	Richmond, Va.
1893	Buckalew, J. H	Mem. & Charleston	Memphis, Tenn.
1887	Buchanan, Wm	N. Y. C. & H. R	New York City.
1891	Burns, C. H	Hous. & Tex. Cent	Houston, Tex.
1870	Bushnell, R. W	B. C. R. & N	Cedar Rapids, Ia.
1893	Butcher, Geo. W	Texas & New Orleans	Houston, Tex.
1861	Butler, L. M.	N. Y. P. & B	Providence, R. I.
1890	Butterly, T. E	Wabash	Moberly, Mo.
1883	Campbell, John	Lehigh Valley	Delano, Pa.
1891	Campbell, John D	N. Y. Cent	Depew, N. Y.
1889	Carmody, T	N. Y. L. E. & W	Cleveland, O.
1885	Carson, M. T	Mobile & Ohio	Jackson, Tenn.
1889	Casanave, F. D	Penn. R. R	Altoona, Pa.
1890	Casey, J. J	L. N. O. & Tex	Vicksburgh, Miss.
1892	Chamberlain, E	Rood & Brown	Lancaster, N. Y.
1893	Chambers, Jno. S	Ill. Central	Amboy, Ill.
1878	Chapman, T. L	Orange Street	East Orange, N. J.
1893	Childs, H. A	N. Y. L. E. & W	Jersey City, N. J.
1870	Clark, David	Lehigh Valley	Hazelton, Pa.
1886	Clark, Isaac W	C. F. & Y. V	Fayetteville, N. C.
1893	Cleaver, F. C	Vandalia	Terre Haute, Ind.
1892	Clifford, C. J	C. & B. Y	South Chicago, Ill.
1887	Clifford, J. G	L. & Nashville	Mobile, Ala.
1887	Cloud, John W	Rookery Building	Chicago, Ill.
1891	Cockfield, Wm	Mexican Central	Jimulco, Mex.
1885	Collier, M. L	W. & Atlantic	Atlantic, Ga.
1891	Collinson, James	A., T. & S. F	Fort Madison, Ia.

JOINED.	NAME.	ROAD.	ADDRESS.
1890	Conolly, J. J	D., S. S. & A	Marquette, Mich.
1892	Conroe, I	A., T. & S. F	La Junta, Col.
1892	Cooley, M. W	Southern Pacific	Fresno, Cal.
1892	Cooper, Charles G	Toledo, Col. & Cin	Kenton, O.
1892	Cooper. H. A	N. Y., L. E. & W	Hornellsville, N. Y.
1879	Cook, John S	Georgia	Augusta, Ga.
1879	Cooke, Allen	Ch. & E. Ill	Danville, Ill.
1891	Cooke, W. I	Tol. & St. L. & K. C	Frankfort, Ind.
1888	Cory, C. H	C. H. & D	Lima, O.
1892	Coxe, Daniel	Del., Sus. & Schuylkill	Drifton, Pa.
1892	Crawford, S. B	B. & O	Mt. Clare, Balt., Md.
1885	Cromwell, A. J	B. & O	Baltimore, Md.
1893	Cross, W	Can. Pac. Ry	Winnipeg. Man.
1883	Cullen, Jas	N. C. & St. L	Nashville, Tenn.
1889	Curran, Peter	N. Y. L. E. & W	Bradford, Pa.
1892	Cushing, G. W		Evanston, Ill.
1892	Dailey, J. B	Rio Grande West	Salt Lake City, Utah.
1888	Dallas, Wilber C		920 Forrest st., St. Paul, Minn.
1890	Davies, J. M	Chateaugay	Lyon Mt., N. Y.
1892	Davis, Ed. E		Boies Car Wheel Works, Scranton, Pa.
1886	Davis, Jas. A	N. T. & Q	Deseronto, Ont.
1893	Davis, W. J	Pitts. & Western	Foxbury, Pa.
1891	Deems, J. F	C. B. & Q	Ottumwa, Ia.
1892	Dehn, F. H	Tex. Cent	Walnut, Tex.
1889	Deibert, F. W	Ch. M. & St. P	Portage, Wis.
1893	Derby, Abram	South Florida	Sanford, Fla.
1890	Derby, R	South Florida	Sanford, Fla.
1887	Dickson, G. L		Dickson Loco. Works, Scranton, Pa.
1887	Dickson, J. P		Dickson Loco. Works, Scranton, Pa.
1890	Dolbeer, Alonza		Rochester, N. Y.
1882	Domville, C. K	Grand Trunk	Hamilton, Ont.
1892	Dorsey, J. B	Ohio River	Parkersburg, W. Va.
1880	Dotterer, D. H		Vacuum Oil Co., Rochester, N. Y.
1890	Downing, T	El. Jol. & Eastern	Joliet, Ill.
1889	Durrell, D. J		Ill. Steel Co., Joliet, Ill.
1881	Eastman, A. G		Sutton, Que.
1868	Eddy, W. H		Springfield, Mass.
1869	Elliott, Henry		E. St. Louis, Ill.
1893	Ellis, John J	C. St. M. & O	St. Paul, Minn.
1893	Elordi, Juan J	P. Rys of Buenos Ayres	La Plata, Argent.
1893	Elwell, J. B	East Louisiana	New Orleans, La.
1893	English, Richard	A. & Pac	Albuquerque, N. M.
1881	Ennis, W. C	N. Y. S. & W	Wortendyke, N. J.
1892	Esson, R. C	So. Pacific	Newark, Cal.

JOINED.	NAME.	ROAD.	ADDRESS.
1885	Fenwick, A	G. B. W. & St. P	Green Bay, Wis.
1885	Ferguson, G. A	Concord & Montreal.	Lakeport, N. H.
1889	Ferry, F. J	L. St. L. & Tex	Cloverport, Ky.
1874	Finlay, L		902 W. 4th st., Little Rock, Ark.
1892	Fitzmorris, James		Union Stock Yards, Chicago, Ill.
1888	Forsyth, Wm	C. B. & Q	Aurora, Ill.
1875	Foster, W. A		Fall Brook Coal Co., Corning, N. Y.
1890	Foulks, John	T. St. L. & K. C	Charleston, Ill.
1877	Fowle, I. W	Col. Midland	Leadville, Col.
1887	Fraser, T. A		Wells & French Car Works, Chicago, Ill.
1891	French, R. F	So. Pacific	Bakersfield, Cal.
1890	Fuller, C. E	Central Vermont	St. Albans, Vt.
1872	Fuller, Wm		213 Kennard st., Cleveland, O.
1891	Galbraith, R. M	St. L., A. & Tex	Tyler, Tex.
1885	Galloway, A.	T. A. A. & N. M	Owosso, Mich.
1890	Garlock, W. H	S. L. S. & E	Seattle, Wash.
1883	Garrett, H. D	Penn	Philadelphia, Pa.
1892	Garrison, C. E	West Shore	E. Buffalo, N. Y.
1887	Garstang, Wm	C. C. C. & St. L	Indianapolis, Ind.
1886	Gentry, T. W	Rich. & Dan	Richmond, Va.
1883	George, Nathan M		Danbury, Conn.
1890	Gessler, Wm	C. R. I. & P	Trenton, Mo.
1888	Gibbs, A. W	Pennsylvania.	Altoona, Pa.
1890	Gibbs, George	C. M. & St. P	Milwaukee, Wis.
1892	Giles, C. F	L. & Nash	Pensacola, Fla.
1891	Gillis, H. A	Nor. & Western	Roanoke, Va.
1883	Gilmore, W. L	L. S. & M. S	Elkhart, Ind.
1890	Givan, F. A		Penn. Lumber Co., Philadelphia, Pa.
1891	Glass, John C	Allegheny Valley	Verona, Pa.
1891	Gleasier, T. W	Mexican Central	Silao, Mex.
1891	Glover, J. B	Marietta & Nor. Ga.	Marietta, Ga.
1880	Gordon, H. D		Juniata Shops, Altoona, Pa.
1879	Gordon, Jas. T	Concord	Concord, N. H.
1891	Gould, Amos	N. Y. C. & H. R	E. Buffalo, N. Y.
1869	Graham, Charles		Scranton, Pa.
1892	Graham, Charles, Jr.	D., L. & W.	Kingston, Pa.
1882	Graham, J. S	L. S. & M. S	Cleveland, O.
1892	Gray, Robert	Southern Pacific	Tucson, Ariz.
1889	Greatsinger, J. L	D. & I. Range	Two Harbors, Minn.
1892	Green, Joseph H	R. & Danville	Columbia, S. C.
1891	Griffin, R. F	D. & I. Range	Two Harbors, Minn.
1885	Griffith, Fred. B	Del., L. & W	Buffalo, N. Y.
1872	Griggs, Albert		15 Wayland st., Dorchester, Mass.
1893	Gross, R. J		Brooks Locomotive Works, Dunkirk, N. Y.

JOINED.	NAME.	ROAD.	ADDRESS.
1880	Hackney, Clem		624 Washington st., Milwaukee, Wis.
1875	Haggett, J. C	D. & A. Valley	Dunkirk, N. Y.
1886	Haggerty, G. A	Canadian Pacific	McAdams Junc., N. B.
	Hainen, R. J	N. Y.. L. E. & W	Port Jervis, N. Y.
1889	Hall, Don Diego	Government Railways	Santiago, Chile.
1883	Hall, J. N		Montgomery, Ala.
1890	Haller, W. J	Ches. & Ohio	Covington, Ky.
1891	Hancock, Geo. A	Gulf Col. & S. Fé	Galveston, Tex.
1893	Hancock, Wm. T., Jr.	A. & Pacific	Needles, Cal.
1893	Hardie, Jas		Hardie & Co., Valparaiso, Chile.
1875	Harding, B. R	R. G., R. & A	Raleigh, N. C.
1888	Harrington, John	Mex. Nor	Escalon, Mex.
1888	Harris, Geo. D	Georgia Southern	Macon, Ga.
1885	Harrison, W. H	B. & O	Newark, O.
1889	Haskell, B	C. & W. Mich	Grand Rapids, Mich.
1888	Hassman, Wm.		
1875	Hatswell, T. J	F. & P. M	E. Saginaw, Mich.
1888	Hazelton, G. H	R. W. & O	Oswego, N. Y.
1890	Hazlehurst, G. B	B. & O	Baltimore, Md.
1891	Hedley, E. M	Brooklyn Elevated	Brooklyn, N. Y.
1891	Hedley, F	Lake Street Elevated	Chicago, Ill.
1888	Hemphill, W. J	Jacks. So. Eastern	Jacksonville, Ill.
1886	Hendee, A.		Westinghouse Air Brake Co., Pittsburg, Pa.
1892	Henderson, G. R	Norfolk & Western	Roanoke, Va.
1882	Henney, J. B		93 Bird st., Boston, Mass.
1887	Heintzleman, T. W.	So. Pac	Sacramento, Cal.
1892	Herr, Edwin M		Grant Loco. Wks., Chicago, Ill.
1877	Hewitt, John		1323 So. Jefferson ave., St. Louis, Mo.
1883	Hickey, John	Nor. Pac	St. Paul, Minn.
1890	Higgins, S	N. Y. P. & O	Cleveland, O.
1887	Hill, Jas. W	Peoria & Pekin Union	Peoria, Ill.
1892	Hill, Rufus.	Penn	Pavonia, N. J.
1892	Hincley, A. C.	St. Jo. & Gr. Island	St. Joseph, Mo.
1885	Hinman, M. L		Brooks Loco. Works, Dunkirk, N. Y.
1870	Hodgman, S. A		Lobdell Car Wheel Co., Wilmington, Del.
1883	Hoffecker, W. L	Cent. of N. J.	Elizabethport, N. J.
1892	Holland, W. D	Guatemala, Nor	Puerto Barrios, G'ala.
1885	Holman, W. L	Penn	Renova, Pa.
1890	Homer, John C		Sta. C., Totton place, Cincinnati, O.
1892	Howard, C. H		Safety Car Heating Co., 160 Broadway, N. Y.
1890	Hudson, E. E	C. C. C. & St. L	Cleveland, O.
1892	Hudson, W. H	E. T. V. & Ga	Atlanta, Ga.
1890	Hufsmith, F	T. & G. N	Palestine, Tex.
1890	Humphrey, A. L	Col. Mid	Colorado City, Col.
1892	Hunt, G. H	So. Pac	Wadsworth, Nev.

JOINED.	NAME.	ROAD.	ADDRESS.
1889	Irby, Chas.	Current River.	Willow Springs, Mo.
1888	Jackson, O. H.		Brightwood, Ind.
1883	Jacques, Richard	Hemenway & Brown, 87 Milk st., Boston, Mass.	
1892	Jenks, E. E.	Penn., P. & Boston	Pen Argyl, Pa.
1892	Jennings, G. W	Mex. Cent	City of Mexico, Mex.
1890	Jennings, Wm	Mex. Inter	Piedras Negras, Mex.
1893	Jerome, E. W.	Zanes. & Ohio	Zanesvile, O.
1878	Johnson, J. B	A. Midland	Helena, Ark.
1887	Johnson, L. R.	Can. Pacific	Vancouver, B. C.
1887	Johnstone, F. W.	Mexican Central	City of Mexico.
......	Jones, W. H	Ches. & Ohio	Richmond, Va.
1888	Joughins, G. R.	Nor. So.	Berkley, Va.
1892	Keegan, Jas. E.	C. R. & I.	Grand Rapids, Mich.
1892	Keeler, Sanford	F. & P. M	E. Saginaw, Mich.
1887	Kells, Leroy	P. C. & St. L.	Cincinnati, O.
1890	Keith, J. M	West. R'y of Guatemala	Retalhuleu, Guat.
1882	Kiehner, John I.	2341 E. York st., Philadelphia, Pa.	
1888	Kiley, M. R.		
1890	Killen, W. E.	Nev. Cent.	Battle Mt., Nev.
1887	Kimball, N. S.	M. & Nor.	Green Bay, Wis.
1868	Kinsey, J. I.	Lehigh Valley	Easton, Pa.
1892	Kirk, John	A. T. & S. F.	Arkansas City, Kan.
1892	Kissler, Lewis	D. L. & W.	Syracuse, N. Y.
1890	Knapp, G.	H. & Shen.	Shenandoah, Ia.
1891	Kredell, R. F.		Chester, Va.
1890	Kulbaugh, I. N.	B. & O	Pittsburg, Pa.
1891	Lamby, T. L.	T., St. L. & K. C	Delphos, O.
1873	Lannan, Wm.	House of Representatives, Washington, D. C.	
1888	Lape, C. F	Wabash	Springfield, Ill.
1882	Lape, J. K.	K C. W. & G.	Lake Charles, La.
1870	Lauder, J. N.	Old Colony	Boston, Mass.
1889	Lavery, W.	N. Y. L. E. & W.	Susquehanna, Pa.
1891	Lawler, F. M.	C. C. C. & St. L	Mattoon, Ill.
1891	Lawes, T. A	C. C. C. & St. L	Indianapolis, Ind.
1890	Leach, H. L.	Fitchburg	Fitchburg, Mass.
1892	Lee, C. W	R. & Danville	Salisbury, N. C.
1883	Leeds, Pulaski	L. & Nash	Louisville, Ky.
1888	Leigh, F. J.	Can. Loco. Works, Kingston, Ont	
1890	Leonard, A. G.	N. Y. Central	New York City.
1873	Lewis, W. H.	D. L & W.	Kingsland, N. J.
1890	Lewis, Wm. H.	C. B. & Nor.	La Crosse, Wis.
1890	Lloyd, T. J.	Ches. & Ohio	Richmond, Va.

JOINED.	NAME.	ROAD.	ADDRESS.
1890	Logan, P. A.	Can. Eastern	Gibson, N. B.
1892	Lord, E. P.		Porter Loco. Works, Pittsburg, Pa.
1868	Losey, Jacob		Steam Forge Co., Louisville, Ky.
1890	Luttgens, H. A.		Rogers Loco. Works, Paterson, N. J.
1890	Luttrell, J. W.	Ill. Central	Chicago, Ill.
1885	Lythgoe, Jos.		R. I. Loco. Works, Providence, R. I.
1887	Macbeth, Jas.	N. Y. Central	Buffalo, N. Y.
1892	Macdonald, A.V.,	Hurunui Bluff, Sec. N. Z. Rys.,	Christchurch, N. Z.
1890	Macfarlane, T. W.	Nor. Pac.	Mandan, N. Dak.
1886	Mackenzie, John	N. Y. C. & St. L.	Cleveland, O.
1892	Mackinnon, Geo.	Can. Pac.	Farnham, Ont.
1878	Maglenn, Jas	Carolina Central	Laurenburg, N. C.
1893	Manning, J. H.	Union Pac.	Omaha, Neb.
1891	Manuell, Geo.	Mobile & Ohio	Jackson, Tenn.
1890	Marshall, E. S.		Madison Car Works, Madison, Ill.
1888	Mayer, A. A.	Gr. Trunk	Stratford, Ont.
1889	May, Edward	Intercolonial	Moncton, N. B.
1892	McCann, Thos.	Georges Creek & Cum.	Cumberland, Md.
1892	McCarthy, J. C.	N. O. & N. E	Meridian, Miss.
1891	McClurg, John	C. C. C. & St. L.	Urbana, Ill.
1891	McConnell, J. H.	Union Pac.	Omaha, Neb.
1890	McCormick, J. H.	C. & P. Sound	Seattle, Wash.
1893	McCracken, J. E.	K. C. O. & S.	Sheffield, Mo.
1890	McCreery, Frank	C. H. & D.	Dayton, O.
1875	McCrum, J. S.	K. C. Ft. S. & G.	Kansas City, Mo.
1892	McCuen, J. P.	Ala. Gr. Southern.	Birmingham, Ala.
1892	McGee, F. H.	Cent. of Ga.	Macon, Ga.
1889	McGrayel, John		Grand Junction, Ia.
......	McDonough, Jas.	Gulf, Col. & S. F.	Galveston, Tex.
1892	McDuff, Allan	B. C. R. & N.	Cedar Rapids, Ia.
......	McElvaney, C. T.	M. K. & Tex.	Dennison, Tex.
1892	McIlwain, J. D.		Harvey Steel Car Wks., Chicago, Ill.
1890	McIntosh, Wm.	Ch. & N. Western	Winona, Minn.
1893	McKee, G. S	C. C. C. & St. L.	Mattoon, Ill.
1891	McKenna, John	I. D. S.	Indianapolis, Ind.
1890	McNaughton, Jas.	Wis. Cent.	Waukesha, Wis.
1888	McNiven, P. C.		Can. Loco. Wks., Kingston, Ont.
1888	Medway, John	Fitchburg	Boston, Mass.
1883	Meehan, Jas.	C. N. O. & T. P.	Ludlow, Ky.
1892	Mertsheimer, F	Union Pacific	Cheyenne, Wyo.
1887	Michael, J. B.	E. T. V. & G.	Knoxville, Tenn.
1883	Middleton, Harvey		Pullman Shops, Pullman, Ill.
1889	Midelton, Thos.		Sydney, N. S. W.
1885	Millen, Thos.	N. Y. C. & N	High Bridge, N. Y.

JOINED.	NAME.	ROAD.	ADDRESS.
1891	Miller, W. H		
1890	Miller, Geo. A	J. St. A. & H.	St. Augustine, Fla.
1889	Miller, E. A	N. Y. C. & St. L.	Conneaut, O.
1890	Mills, Stott.	Lehigh & Hudson	Warwick, N. Y.
1893	Minshull, P. H.	N. Y. O. & W.	Middleton, N. Y.
1892	Minto, H. M	L. & Nash	Mobile, Ala.
1888	Minton, A. B.	Mobile & Ohio	Murphysboro, Ill.
1892	Mitchell, Alva	A. T. & S. F.	Ottawa, Kan.
1870	Mitchell, A.	Lehigh Valley	Wilkesbarre, Pa.
1892	Mitchell, A. E.	N. Y., L. E. & W.	New York City.
1890	Monkhouse, H	C., R. I. & P	Horton, Kan.
1888	Montgomery, Wm	Cent. of N. J.	Manchester, N. J.
1890	Moore, J. H.	N. Y., L. E. & W.	Elmira, N. Y.
1882	Morrell, J. E	C., R. I. & P.	Davenport, Ia.
1887	Morris, W. S.	Ches. & Ohio	Richmond, Va.
1890	Morse, F. W	Wabash	Ft. Wayne, Ind.
1876	Morse, G. F	Portland Loco. Works,	Portland, Me.
1890	Morse, W. M	T. & O. C. E.	Marietta, O.
1891	Mott, D. G	Panama	Colon, Colombia.
1893	Mottershead, Peter	Ch. & N. Western	Boone, Ia.
1890	Murphy, P. H.	Murphy Car Roof Co.,	East St. Louis, Ill.
1892	Nauffer, John G.	B. O. & S. W.	Chillicothe, O.
1890	Nicholls, J. Mayne	Ferro Caril	Iquique, Chile.
1875	Noble, L. C	A. French Spring Co.,	Pittsburg, Pa.
1890	O'Brien, John	Rich. & Petersburg	Manchester, Va.
1892	O'Brien, Geo. W	Cent. of Ga.	Augusta, Ga
1890	O'Herin, Wm.	Mo., Kan. & Tex	Parsons, Kan.
1891	O'Keefe, Geo. A	Det., Lan. & Nor.	Ionia, Mich.
1892	Ott, Geo. R.	B. & O	Garrett, Ind.
1890	Page, H. D.	Ch. & N. Western	Baraboo, Wis.
1891	Papineow, F. G	So. Pac.	Houston, Tex.
1891	Pattee, J. O.	Gr. Nor	St. Paul, Minn.
1879	Patterson, J. S.	523 Phœnix Bldg.,	Chicago, Ill.
1885	Paxson, L. B.	P. & Reading	Reading, Pa.
1891	Paxton, Thos	A. T. & S. F.	Nickerson, Kan.
1887	Peck, Peter H.	C. W. I. & B	Chicago, Ill.
1890	Petriken, C. L	Union Iron Works Co.,	Selma, Ala.
1868	Perry, F. A.	Cheshire	Keene, N. H.
1889	Phelan, J. E	Nor. Pac	Dickinson, Dak.
1878	Pilsbury, Amos	Maine Cent.	Waterville, Me.
1885	Pitkin, A. J	Schenectady Loco. Wks.,	Schenectady, N. Y.

JOINED.	NAME.	ROAD.	ADDRESS.
1874	Place, T. W	Ill. Cent	Waterloo, Ia.
1881	Player, John	A. T. & S. F	Topeka, Kan.
1893	Potter, G. S	Penna. Lines	Ft. Wayne, Ind.
1873	Prescott, G. H	T. H. I. & St. L	Terre Haute, Ind.
1891	Prescott, C. H	Spokane Falls & Nor	Spokane Falls, Wash.
1890	Price, Wm. D	P. A. & Western	Delphos, O.
1892	Priest, H. F	Duluth, Missabe & Nor	Duluth, Minn.
1881	Pringle, R. M		1101 North Second st., St. Louis, Mo.
1891	Pullar, John	A. & Pacific	Winslow, Ariz.
1890	Purves, T. B., Jr	B. & A	E. Albany, N. Y.
1892	Putnam, G. V	F. S. & G	Gloversville, N. Y.
1887	Quackenbush, A. W	St. L. Cape G. & Ft. S	Cape Girardeau, Mo.
1888	Quayle, Robert	M. L. S. & W	S. Kaukauna, Wis.
1888	Quinn, John A	C. V. & C	Mt. Carmel, Ill.
1890	Ramsay, J. C	Ill. Central	Memphis, Tenn.
1890	Randolph, L. S	Baltimore Electric Refining Co., Baltimore, Md.	
1889	Ranson, T. W		629 Lake st., Cleveland, O.
1891	Rearden, Frank	Missouri Pac	St. Louis, Mo.
1892	Redding, R. E	Elevated	New York.
1888	Reed, W. T	Ch. St. P. & K. C	St. Paul, Minn.
1890	Reid, M. M	Nor. So	Berkley, Va.
1890	Reiley, B	Minn. & St. L	Minneapolis, Minn.
1890	Remex, B. H. de	D. & R. G	Leadville, Col.
1883	Renshaw, W	Ill. Cent	Chicago, Ill.
1892	Rettew, C. E	D. & H. C	Carbondale, Pa.
1887	Reynolds, W. W	C. St. L. & P	Columbus, O.
1888	Rhodes, G. W	C. B. & Q	Aurora, Ill.
1883	Richardson, E	S. & Allegheny	Greenville, Pa.
1889	Rickard, C. W	A. T. & S. F	Raton, N. M.
1890	Riley, G. M. D	Sav., Fla. & Western	Savannah, Ga.
1882	Roberts, E. M	E. T. V. & G	Charleston, S. C.
1891	Roberts, Wood	St. L. I. M. & S	Little Rock, Ark.
1885	Robertson, W. J	C. Vermont	St. Albans, Vt.
1890	Robinson, John	L. S. & M. S	Buffalo, N. Y.
1891	Rogers, M. J		
1890	Rommel, George	Wil. & Nor	Wilmington, Del.
1882	Ross, Geo. B		Box 326, Buffalo, N. Y.
1892	Rotherham, T. F	New Zealand Gov't	Wellington, N. Z.
1891	Russell, W. R	Q. M. & C	Quebec, Can.
1890	Rutherford, Wm	Fla. So	Palatka, Fla.
1892	Ryan, Pat	L. & Nash	Russellville, Ky.
1891	Ryan, J. J	So. Pacific	Houston, Tex.
1891	Ryder, Henry	Housatonic	Falls Village, Conn.

JOINED.	NAME.	ROAD.	ADDRESS.
1892	Sague, J. E.	Schenectady Loco. Works	Schenectady, N. Y.
1887	Sample, N. W.	D. & R. G	Denver, Col.
1891	Sanborn, J. N.	C. M. & St. P.	Clinton, Ill.
1890	Savage, R. W	St. L. A. & Tex.	Tyler, Tex.
1874	Schlacks, Henry		Chicago, Ill.
1891	Schreiber, P. H.	C. N. O. & T. P.	Chattanooga, Tenn.
1875	Sedgwick, V. E.	Mex. Nat	Tampico, Mex.
1882	Selby, W. H.		Box 1503, Moberly, Randolph Co., Mo.
1869	Setchel, J. H.		Cuba, N. Y.
1890	Seward, J. P.	A. & B. Short Line	Annapolis, Md.
1892	Shackford, C. E.	Mex. Cent.	San Luis Potosi, Mex.
1890	Shafer, J. C.		
1870	Shaver, D. O.	Penn.	Pittsburg, Pa.
1890	Sheahan, J. F	Orange Belt	Oakland, Fla.
1891	Sheer, Jas. M.	Ohio & Miss.	Washington, Ind.
1890	Sheerer, E. P.	Des Moines Union	Des Moines, Ia.
1890	Shields, J. C.	Mineral Range	Hancock, Mich.
1892	Sheppard, S. A.	T. & Gulf	Clermont, Fla.
1890	Silvius, E. T	J. St. A. & H. R.	St. Augustine, Fla.
1883	Sinclair, Angus		5 Beekman street, New York City.
1892	Sinnott, W.	B. & O.	58th street, Phila, Pa.
1880	Sitton, J. B.	Mex. Nat	Laredo, Tex.
1889	Skinner, H. M. C.		2 Walnut street, Fall River, Mass.
1893	Slater, Frank	M. L. S. & West	Kaukauna, Wis.
1892	Slater, J. C.	Nev. Central	Battle Mt., Nev.
1889	Small, H. J.	So. Pac.	Sacramento, Cal.
1887	Small, W. T.	B. R. & P.	Rochester, N. Y.
1886	Smart, C. E.	Mich. Cent.	Jackson, Mich.
1893	Smith, F. B.	N. Y. P. & O.	Meadville, Pa.
1890	Smith, Geo. W.	A. T. & S. F.	Topeka, Kan.
1892	Smith, John L.	N. Y., L. E. & W.	Bradford, Pa.
1891	Smith, Wm.	Ch. & N. Western	Chicago, Ill.
1869	Smith, W. T.	Newport News & M. V.	Lexington, Ky.
1891	Soule, R. H.	Nor. & Western	Roanoke, Va.
1868	Sprague, H. N.		Pittsburg, Pa.
1893	Stalder, A. W.	F. Ft. W. & W.	Findlay, O.
1890	Stamelen, F.	Erie & Huron	Chatham, Ont.
1872	Stearns, W. H.	Conn. River	Springfield, Mass.
1887	Stephens, S. A.	R. I. Loco. Works	Providence, R. I.
1874	Stevens, Geo. W.	L. S. & M. S.	Cleveland, O.
1892	Stewart, Andrew F.	Ches. & Ohio	Huntington, W. Va.
1885	Stewart O.		152 No. avenue, Cambridge, Mass.
1890	Stillman, H.	S. D. & S. Pac.	Dunsmuir, Cal.
1885	Stinard, F. A		143 Park ave., Paterson, N. J.
1883	Stokes, J. W.	St. L. & T. H.	E. St. Louis, Ill.

JOINED.	NAME.	ROAD.	ADDRESS.
1887	Stone, W. A	L. E. & St. L	Huntingburg, Ind.
1890	Stout, Henry K	Penn	Sunbury, Pa.
1875	Strode, Jas	N. Cent	Elmira, N. Y.
1891	Strom, L	Sonora	Nogales, Ariz.
1890	Studer, A. L	C. R. I. & P. S	Stuart, Ia.
1883	Sullivan, A. W.	Ill. Cent	Chicago, Ill.
1891	Sullivan, J. J	Louisville So	Harrodsburg, Ky.
1891	Summerskill, T. A	M. & N. West	Portage, Man.
1892	Sumner, Eben T	B. & M	E. Cambridge, Mass.
1892	Sutherland, R. D	Boston, R. B. & Lynn	Boston, Mass.
1868	Swanston, Wm.	C., St. L. & P	Indianapolis, Ind.
1892	Symons, W. E	A. T. & S. F	Raton, N. M.
1893	Tabor, W. G	Da., V. & T	Dunkirk, N. Y.
1883	Tandy, H	Brooks Loco. Wks., Dunkirk, N. Y.	
1886	Thatcher, Thos	D. L. & W	Utica, N. Y.
1885	Thomas, C. F	R. & Danville	Alexandria, Va.
1891	Thomas, H. J	D. B. C. & A	E. Tawas, Mich.
1892	Thomas, J. J., Jr	Birmingham & Atlantic	Talladega, Ala.
1883	Thomas, W. H	E. T. V. & G	Knoxville, Tenn.
1890	Thomas, W. J	North P. Coast	Sausalite, Cal.
1890	Thompson, C. A		Richmond Hill, N. Y.
1883	Thow, Wm	Government	Sydney, N. S. W.
1892	Todd, Louis C	B. & M	Lyndonville, Vt.
1892	Tomlinson, Jas. G	Ala. Gr. So	Birmingham, Ala.
1893	Tonge, John	M. & St. L	Minneapolis, Minn.
1885	Torrence, John	E. & T. H	Evansville, Ind.
1892	Townsend, Jos	Ch. & Alton	Bloomington, Ill.
1892	Traver, W. H	A. T. & S. F	Argentine, Kan.
1883	Tregelles, Henry	Norton, Megaw & Co., Rio de J., Brazil.	
1892	Tremp, A. E	Ohio So	Springfield, O.
1892	Tresize, Thos	B. & O	Philadelphia, Pa.
1890	Tuggle, S. R	Kentucky Cent	Covington, Ky.
1890	Turner, Calvin G	Phil., Wil. & Balt	Wilmington, Del.
1889	Turner, Chas. E	W. N. Y. & Pa	Olean, N. Y.
1886	Turner, J. S	Eames Vacuum Brake Co., New York City.	
1890	Turner, L. H	Pitts. & L. Erie	Chartiers, Pa.
1886	Twombly, A. W	Old Colony	Taunton, Mass.
1883	Twombly, Fred M	Old Colony	Boston, Mass.
1890	Tyerell, Thos. H	S. I. R. T	Whitehall st., N. Y.
1887	Tynan, F. F	Ferre Carriles Unidos de la Habana	Habana, Cuba.
1885	Ulmo, H. A	C. & Savannah.	Savannah, Ga.
1872	Underhill, A. B	B. & Albany	Springfield, Mass.
1889	Vail, A	W. N. Y. & Pa.	Buffalo, N. Y.
1890	Van Brunt, G. E	Penn. & N. Western	Bellwood, Pa.

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Constitution and By-Laws.

ARTICLE I.

NAME.

The name of this association shall be the AMERICAN RAILWAY MASTER MECHANICS' ASSOCIATION.

ARTICLE II.

OBJECTS OF THE ASSOCIATION.

The objects of this association shall be the advancement of knowledge concerning the principles, construction, repair and service of the rolling-stock of railroads, by discussions in common, the exchange of information, and investigations and reports of the experience of its members; and to provide an organization through which the members may agree upon such joint action as may be required to give the greatest efficiency to the equipment of railroads which is intrusted to their care.

ARTICLE III.

MEMBERSHIP.

SECTION 1. The following persons may become active members of the association, on being recommended by two members in good standing, signing an application for membership and agreement to conform to the requirements of the Constitution and By-Laws, or authorizing the Secretary to sign the Constitution for them :

(1.) Those above the rank of general foremen, having charge of the design, construction or repair of railway rolling-stock.

(2.) General foremen, if their names are presented by their superior officers.

(3.) Two representatives from each locomotive and car-building works.

SEC. 2. Civil and mechanical engineers, or other persons having such a knowledge of science or practical experience in matters pertaining to the construction of rolling stock as would be of special value to the association or railroad companies, may become associate members on being recommended by three active members. The name of such candidate shall then be referred to a Committee, to be appointed by the President, which shall investigate the fitness of the candidate and report to the Executive Committee of the association at the next annual meeting. If the report be unanimous in favor of the candidate the name shall be submitted to ballot, and five dissenting votes shall reject. The number of associate members shall not exceed twenty, and they shall be entitled to all the privileges of active members, excepting that of voting.

SEC. 3. All members of the association, excepting as hereafter provided, shall be subject to the payment of such annual dues as it may be necessary to assess for the purpose of defraying the expenses of the association, provided that no assessment shall exceed five dollars a year.

Such dues shall be payable when the amount thereof is announced by the President, at each annual meeting. Any member who shall be two years in arrears for annual dues, shall be notified of the fact, and if the arrears are not paid within three months after such notification, his name shall be taken from the roll and he be duly notified of the same by the Secretary.

SEC. 4. Any person who has been or may be duly qualified as a member of this association will remain such until his resignation is voluntarily tendered, or he becomes disqualified by the terms of this Constitution. Members whose names have been dropped for non-payment of dues may be restored to membership by the unanimous consent of the Executive Committee on the payment of all back dues.

SEC. 5. Members of the association who have been in good standing for not less than five years, and who through age or other cause cease to be actively engaged in the mechanical department of railway service, may, upon the unanimous vote of the members present at the annual meeting, be elected Honorary

Members. The dues of the Honorary Members shall be remitted, and they shall have all the privileges of active members, except that of voting.

SEC. 6. Any member who, during the meetings of the association, shall be guilty of dishonorable conduct which is disgraceful to a railroad officer and a member of the association, or shall refuse to obey the chairman when called to order, may be expelled by a two-thirds affirmative vote at any regular meeting of the association held within one year from the date of the offense.

ARTICLE IV.

OFFICERS.

SEC. 1. The officers of the association shall be a President, a First Vice-President, a Second Vice-President, a Treasurer and a Secretary, and they shall constitute the Executive Committee.

ARTICLE V.

DUTIES OF OFFICERS.

SEC. 1. It shall be the duty of the President to preside at all the meetings of the association, appoint all Committees—designating the chairman, and approve all bills against the association for payment by the Treasurer.

SEC. 2. It shall be the duty of the Vice-Presidents, according to rank, to perform the duties of the President in his absence from the meetings of the association.

SEC. 3. In case of the absence of both President and Vice-Presidents, the members present shall elect a President *pro tempore*.

SEC. 4. It shall be the duty of the Secretary to keep a full and correct record of all transactions at the meetings of the association; to keep a record of the names and places of residence of all members, and the name of the railway they each represent; to certify to the persons who are eligible as candidates for the association's scholarships at the Stevens Institute of Technology; to receive and keep an account of all money paid to the association and deliver the same to the Treasurer, taking his receipt for the amount; to receive from the Treasurer all paid bills, giving him a receipted statement of the same.

SEC. 5. It shall be the duty of the Treasurer to receive all money from the Secretary belonging to the association; to receive all bills and pay the same, after having approval of the President; to deliver all bills paid to the Secretary at the close of each meeting, taking a receipted statement of the same, and to keep an accurate book account of all transactions pertaining to his office.

ARTICLE VI.

EXECUTIVE COMMITTEE.

SEC. 1. The Executive Committee shall exercise a general supervision over the interests and affairs of the association, recommend the amount of the annual assessment, to call, to prepare for, and to conduct general Conventions, and to make all necessary purchases, expenditures and contracts required to conduct the current business of the association, but shall have no power to make the association liable for any debt to an amount beyond that which at the time of contracting the same shall be in the Treasurer's hands in cash, but not subject to prior liabilities. All expenditures for special purposes shall only be made by appropriations acted upon by the association at a regular meeting.

SEC. 2. The Executive Committee shall receive, examine and approve before public reading, all communications, papers and reports on all mechanical and scientific matters; they shall decide what portion of the reports, papers and drawings shall be submitted to each Convention and what portion shall be printed in the annual report.

SEC. 3. Three members shall constitute a quorum for the transaction of business.

SEC. 4. The Executive Committee shall form with a Committee of the Master Car Builders' Association a Joint Committee to decide on the place of meeting for the Annual Convention.

ARTICLE VII.

ASSOCIATION SCHOLARSHIPS.

It shall be the duty of the Secretary to issue a circular annually intimating the date and place when and where candidates may

be examined for the scholarships of the association in the Stevens Institute of Technology, Hoboken, N. J.

Acceptable candidates for the scholarships are the sons of members of the association in good standing, the sons of honorary members and sons of deceased active or honorary members who may have died while in good standing. Candidates for these scholarships shall apply to the Secretary of this association, and if found eligible shall be given a certificate to that effect for presentation to the school authorities. This will entitle the candidate to attend the preliminary examination. If more than one candidate passes the preliminary examination, the applicant passing the highest examination shall be entitled to the scholarship, the school authorities settling the question.

The candidates for these scholarships must have at least one year's experience in some recognized machine shop. The successful candidate shall also be required to take the course of mechanical engineering.

ARTICLE VIII.

ELECTION OF OFFICERS.

SEC. 1. The officers of the association shall be elected by ballot separately without nomination at the regular meeting of the association, held in June of each year. A majority of all votes cast shall be necessary to an election, and elections shall not be postponed.

SEC. 2. Two tellers shall be appointed by the President to conduct the election and report the result.

ARTICLE IX.

AUDITING COMMITTEE.

SEC. 1. At the first session of the annual meeting an Auditing Committee, consisting of three members not officers of the association, to be nominated by any member who does not hold office, shall be elected in the same way as officers are voted for. This Auditing Committee shall examine the accounts and vouchers of the Treasurer and certify whether they have been found correct or not. After the performance of this duty they shall be discharged by the acceptance of their report by the association.

COMMITTEE ON SUBJECTS FOR INVESTIGATION AND DISCUSSION.

SEC 2. At each annual meeting the President shall appoint a Committee whose duty it shall be to report at the next annual meeting subjects for investigation and discussion, and if the subjects are approved by the association the President, as hereinafter provided, shall appoint Committees to report on them. It shall also be the duty of the Committee to receive from members questions for discussion during the time set apart for that purpose. This Committee shall determine whether such questions are suitable ones for discussion, and if so, they shall so report them to the association.

COMMITTEES ON INVESTIGATION.

SEC. 3. When the Committee on Subjects has reported, and the association approved of subjects for investigation, the President shall appoint special Committees to investigate and report on them, and may authorize and appoint a *special* Committee to investigate and report on any subject which a majority of the members present may approve.

ARTICLE X.

AMENDMENTS.

SEC. 1. This Constitution may be amended at any regular meeting by a two-third vote of the members present, provided that written notice of the proposed amendments has been given at a previous meeting at least six months before.

By-Laws.

TIME OF MEETING.

I. The regular meeting of the association shall be held annually on the Monday after the second Tuesday in June.

HOURS OF SESSION.

II. The regular hours of session shall be from nine o'clock A. M. to two o'clock P. M.

PLACE OF MEETING.

III. Places for holding the Annual Convention shall be selected by a Joint Committee composed of the President, two Vice-Presidents, Secretary and Treasurer of this association, and the President, three Vice-Presidents and Secretary of the Master Car Builders' Association. This Joint Committee shall meet within six months after the Convention and decide upon a place of meeting, the place receiving the largest number of votes to be selected.

QUORUM.

IV. At any regular meeting of the association, fifteen or more members entitled to vote shall constitute a quorum.

ORDER OF BUSINESS.

V. The business of the meetings of this association shall, unless otherwise ordered by a vote, proceed in the following order:

1st. Opening prayer.
2d. Address by the President.
3d. Calling the roll.
4th. Acting on the minutes of the last meeting.
5th. Reports of Secretary and Treasurer.
6th. Assessment and announcement of annual dues.

7th. Election of Auditing Committee.
8th. Unfinished business.
9th. New business.
10th. Reports of Committees.
11th. Reading of papers and discussion of questions propounded by members.
12th. Routine and miscellaneous business.
13th. Election of officers.
14th. Adjournment.

QUESTIONS FOR DISCUSSION, SPECIAL ORDER OF.

VI. Unless otherwise ordered, the discussion of questions proposed by members shall be the special order from 12 o'clock M. to 1 P. M. of each day of the annual meeting.

DECISIONS.

VII. The votes of a majority of the members shall be required to decide any question, motion or resolution which shall come before the association, unless otherwise provided.

DISCUSSIONS.

VIII. No patentees or their agents shall be admitted in the meetings of the association for the purpose of advocating the claims of any patent or patentee, unless by unanimous consent.

IX. No member shall speak more than twice in the discussion of any question until all the other members who want to speak, and have not been heard, have spoken.

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American Railway Master Mechanics' Association

(INCORPORATED).

OFFICERS FOR 1893-1894.

PRESIDENT,
JOHN HICKEY,
St. Paul, Minn.

FIRST VICE-PRESIDENT,
WILLIAM GARSTANG,
Indianapolis, Ind.

SECOND VICE-PRESIDENT,
R. C. BLACKALL,
Albany, N. Y.

TREASURER,
O. STEWART,
Charlestown, Mass.

SECRETARY,
ANGUS SINCLAIR,
New York.

Proceedings.

PRELIMINARY.

The Twenty-sixth Annual Convention of the American Railway Master Mechanics' Association was called to order at 9:30 A. M., at Lakewood, N. Y., by President Hickey.

Prayer was offered by Mr. George Royal.

The address of President Hickey was then presented, as follows:

PRESIDENT'S ADDRESS.

GENTLEMEN OF THE AMERICAN RAILWAY MASTER MECHANICS' ASSOCIATION: It is with much pride and no little pleasure that I appear before you this morning to salute you and extend to you a hearty welcome to this Convention, the twenty-sixth in the annals of the association.

At the threshold of this address allow me to express the sincere hope that your stay in this beautiful and well-selected spot will not only reach the full measure of social enjoyment, but that the practical work of this Convention will produce results as gratifying to the promoters of mechanical progress, will display as much zeal and devotion to the great interests which we are representing, and will be as earnest in its efforts to develop appliances for the safety, the convenience and the comfort of the traveling public as any that have preceded it. It is particularly gratifying to announce that our association is in an excellent condition of growth and prosperity. Our membership is steadily increasing with men of a high order of thought and ability. The influence and work of our association is recognized and supported by the highest and ablest railroad officers on this continent and the conclusions of our committees of record are regarded as authority by the deepest mechanical thinkers of all progressive nations.

While we take much pleasure, however, in remembering the good work of this association in the past, it is well to keep in mind that we are in the midst of a most enlightened and progress-

ive age, and that our work must keep pace and be in harmony with the surroundings of advancement, and that we must awake not only to increased activity in dealing with new questions, but must deal with older ones from an advanced standpoint.

I venture the assertion that every member of the association is confronted to a greater or lesser degree with the question of labor.

The situation of the labor problem to-day is not only causing more general uneasiness to the corporations in whose interest our labors are directed, but is the source of considerable anxiety to the essential principles underlying national property.

While it is true that members of this Convention have to deal with but a moderate proportion of those who make up the rank and file of the laboring classes, it is also true that those comprising that proportion are to a large degree the guiding element. It will therefore be reasonable to assume that, when dealing in our official capacity with this question, we are either laying the foundation of peace and harmony with the working people or sowing the seed of civil strife and disorder. It seems entirely proper that the members of this association, both individually and collectively, use all reasonable efforts towards harmonizing a situation of circumstances fraught with so much interest to all.

Public sentiment, if not legislation, guarantees equal rights to the masses. The march of civilization is onward and upward. All who are placed in authority should be considerate of the rights and welfare of their employés. A desire for betterment in the situation and surroundings of the workingman is a natural and human aspiration. To those at least who have been raised and educated among us these conditions seem to be an inherited right.

While business interests cannot possibly at all times comply with the demands and conditions of labor exponents, their requests should always be met and treated in a friendly spirit, and be considered and decided from the position of justice and fair play.

An arrogant manner and impatient consideration in dealing with our employés has too often been followed by unceasing annoyance, disquietude and unsatisfactory service, while honest recognition of reasonable requests has solved many a labor difficulty and prevented much lawless strife.

Tyrannical and arbitrary expressions of power have driven

thousands of workmen to seek revenge in protective organizations, and we have many times condemned arbitrary acts of their champions when probably ourselves have laid the foundations.

No better plans to nullify the teachings of the labor demagogue can be adopted than to meet reasonable demands of the workingmen in the spirit of honesty, candor and fairness, and by advice and action to make them feel that labor well performed is appreciated, and that they will be protected against injustice (which is usually the result of hasty decision) and that faithfulness to duty means continued employment, promotion and protection to themselves and families.

A little reflection will show that an immense forward movement of late years has taken place in the handling and construction of our locomotives, and it will not be exceeding the limits of reasonable modesty in claiming for this association the credit of this development, but in the advanced and progressing currents of time further economy in the expense of operating seems absolutely necessary.

A majority of the largest roads throughout the country, show an operating expense of from 22 to 25 cents per locomotive mile run. About 50 per cent. of this amount is chargeable to fuel consumed in generating power.

Under the ordinary conditions of operating simple engines, we are exhausting to the atmosphere steam containing nearly 50 per cent. of its original value. To obviate this waste of power, various modifications of the valve motion of simple engines have been attempted and tested, but with little, if any, ultimate success.

Much of this waste of power is undoubtedly due, not to the valve motion, when its functions are properly performed, but it is the effect of cause which makes necessary a violent exhaust for the purpose of creating a blast on the fire equal in intensity to the stress of the duty performed.

The point is to eliminate the necessity of this rapid and continuous production of a given amount of excessive heat in a given time without detracting from the hauling efficiency of the locomotive.

Plainly, boilers of a larger capacity than are generally used, containing an increased amount of heating surface, possessing the highest facilities for proper combustion, thus reducing the neces-

sity of a high velocity of the heated currents, must be followed by the most satisfactory results in permitting a larger percentage of the generated heat being imparted to the water, and proportionately reducing the necessity of intensified blast.

Another means of attempting to utilize a higher percentage of the heat and power produced is the introduction of the compound principle in locomotives.

A superficial view of the principles of compounding properly applied would appear to leave little, if any, doubt of its success.

Additional machinery, however, involving an increased number of parts, enhancing the first cost and of necessity adding to the cost of maintenance, are essential questions when considering the policy of the introduction of compound locomotives.

However, experience in practical tests with the compound engine, particularly where the dimensions were adapted closely to the work to be performed, has been so satisfactory and so productive of expected results, that a continuance of these principles, as a matter of economy, is worthy of the highest consideration.

From information at hand on this subject, the performance of the compound has compared unfavorably with the simple engine only where the dimensions of the former were not as properly adapted to the conditions of the service as the latter.

I have in mind many reports of comparative tests between simple and compound engines, showing enormous gains on the side of the latter. Where these conditions exist, it may be well to suspect that the excessive economy shown is only apparent, and may be due, not so much to the compound principle as to the unprofitable performance of the simple engine, because of its improperly proportioned parts, or its incomplete condition.

Highly drawn service tests between simple and compound locomotives are not always commendable, because the usual conditions under which the tests are conducted are often so widely different from those obtained in ordinary service, that results thus procured should hardly be regarded as conclusive.

Comparative tests can be obtained with a much greater degree of profit by placing the engines in regular and parallel service extending over a period of several months, basing their performance on the tonnage hauled, thus demonstrating not alone the fuel-

saving properties, but establishing to a certainty their relative costs of maintenance.

The cost of repairs in maintenance of locomotives is an expense of much importance, the average of the largest roads reaching nearly 4¾ cents per engine mile.

The maintenance of boilers contributes largely to this account, and it appears to me to be one of the most important duties of this association to prosecute investigation to the end of obtaining the most durable material for boiler construction, and also the most durable coupled with the most capable of performing the necessary functions of the firebox plate.

In this same connection, sufficient water space for free circulation between the inner and outer sheets of firebox, and size and material for stay-bolts, should receive more than a passing notice.

The manner of handling boiler plate during boiler construction is also deserving of special attention.

I may be pardoned if I remind the association of the necessity of increased bearing surfaces in all parts of machinery subject to wear from friction.

With increased bearing surfaces we obtain a decreased pressure per unit of contact, thus insuring more perfect lubrication and lessening the cost of maintenance by reduced wear.

The bearing surfaces of crank-pins, eccentrics, links, guides, etc., can be enlarged from 30 to 40 per cent. on present practice with much benefit.

Eliminating straps, keys, and bolts in all connecting and parallel rods, will be found to result in much labor saving.

Improved construction of driving boxes should also be looked upon with much favor.

It is within easy reach to design a box with an improved method of introducing the bearing brass, that will render double the mileage of that used in ordinary service at the present.

I have frequently heard conflicting opinions regarding proper size of crank-pins, able to bear with ease and safety the stresses exerted by cylinders of various capacities.

Proper dimensions of driving-axles, journals and truck-journals to bear certain loads have also been a source of contention, and, it seems to me, are necessary questions for this association to take up

for investigation, that it may be able to recommend proper dimensions and best material for these parts.

It seems altogether clear that a tonnage rating of engines is the only proper plan, and one that should be universally practiced.

I am fully aware that under some conditions of service the number of tons in a train is not easily attainable without involving some difficulty and delays, but I am far from believing that any serious objections can long exist in the way of obtaining the accurate tonnage of trains in transit.

Knowing the dimensions, it is easy enough to establish theoretically the maximum hauling power of a locomotive. The figures thus reached, however, are not always supported in practical service; hence the frequent disappointment in the actual power developed by locomotives.

It seems within easy reach of invention to devise a means of indicating in a simple way the actual stress or pull exerted on the engine draw-bar at all times.

This dynamometer-like arrangement could be applied to the draw-gear of the tender, and with the aid of a graduating indicator, placed where the extent of pull could be seen and noted, would be a most convenient and desirable locomotive attachment.

The maximum power of a locomotive being thus established in a practical way for certain districts and divisions, and a reasonably accurate train tonnage being known, would obviate much confusion and dispute, and add materially to the efficiency of the train service. These conditions would also serve to point out the men and the engines coming nearest to performing maximum duty.

Our country affords the greatest opportunity for educating the youth of any on the face of the globe. The American people, in their laudable anxiety, have spared neither pains, means, nor efforts towards educating the rising generation. There can hardly be any excuse, therefore, for any of our youth reaching the age of maturity without at least a moderately acquired common school education, yet how often we meet those who are absolutely illiterate.

It seems to me to be the plain duty of all intelligent bodies to aid in the spread of enlightenment and education of the people, and I am of the opinion that no better plan can be adopted by the members of this or sister associations than to refuse to employ any who are not possessed of a reasonably fair education.

It is a very noticeable fact that efficiency in the service is promoted in proportion to the education and intelligence of our employés.

The questions coming before you at this Convention are exceedingly important, and the reports of the committees are full and exhaustive, and I beg to ask your undivided attention to the report of each committee as it is presented.

Permit me also to repeat the hope that the great zeal you have heretofore shown in all subjects coming before you may be continued, and that deep and considerate thought in every instance may take the place of hasty conclusions. It is not the quantity of our work so much as its quality that bears the most fruit.

I respectfully ask the attention of the association to the necessity of having a standing advisory committee, whose duty it would be to advise with and consult members on any disturbing and unsettled question relating to the interests we represent, as well as to arbitrate matters of difference arising between persons selling, leasing or renting rolling stock, or in the construction of new machinery, and to otherwise perform the duties of an advising and arbitrating committee of the Master Mechanics' Association.

The Great Master Mechanic of the Universe in His deep wisdom has seen fit to remove from our midst twelve of our members in the past year. The secretary, in his report, will read the names of those who have departed never to return. I trust suitable action by the association will be taken to perpetuate their memory.

I would be ungenerous to the members of this association and untrue to my own feelings did I not publicly acknowledge my highest appreciation of my election as president one year ago, and I beg to assure you that the honor thus conferred, together with your words of deep sympathy, extended at a period of my saddest bereavement in the loss of beloved children, are tender memories of my heart, which will only fade from it when it ceases to pulsate.

In this Columbian year, when American inventive power, energy and enterprise have developed an exhibition, which for progressive ingenuity in the formation and display of the works of art is unparalleled in the history of the world, it is but proper that this association join in word, in sentiment and in deed this great educator of the human race.

Its edifying example should also inspire us to thoughts and labors of the highest order, and now as we face the sunrise of the second quarter of a century in the history of the association, our work should be tempered with such reasonings of wisdom that we may with credit to ourselves transmit it to others in such an advanced condition of growth as shall bear witness of our faithfulness and our devotion to the aims and interests of the association.

Members Present at Lakewood Convention.

Secretary Sinclair called the roll and the following members were present at this or subsequent sessions :

ALDCORN, THOS.,
ALLEN, G. S.,
AMES, L.,
ANDERSON, J. J.,
ANTZ, OSCAR,
ARP, W. C.,

BALL, A. J.,
BARNETT, J. DAVIS,
BEAN, JOHN,
BEAN, S. L.,
BERRY, J. H.,
BILLINGHAM, JOS.,
BISSET, JOHN,
BLACKALL, R. C.,
BLACKWELL, CHAS.,
BOND, I.,
BOON, J. M.,
BRADLEY, W. F.,
BREHM, W. H.,
BROOKE, GEORGE B.,
BROWN, DAVID,
BROWN, W. A.,
BRUCK, HENRY T.,
BRYAN, H. S.,
BRYANT, J. T.,
BUCKALEW, J. H.,
BURNS, C. H.,
BUSHNELL, R. W.,

CAMPBELL, JOHN,
CAMPBELL, JOHN D.,
CARMODY, T.,
CASEY, J. J.,
CHILDS, H. A.,
CLARK, DAVID,
CLARK, ISAAC W.,
CLEAVER, F. C.,
CLIFFORD, C. J.,
COOPER, CHAS. J.,
COOK, JOHN S.,
CORY, C. H.,

DAVIS, ED. E.,
DOLBEER, ALONZA,
DORSEY, J. B.,
DOWNING, T.,

ELLIS, JOHN J.,
ENNIS, W. C.,

FORSYTH, WM.,
FOSTER, W. A.,
FRENCH, R. E.,
FULLER, C. E.,
FULLER, WM.,

GARRISON, P. E.,
GENTRY, T. W.,
GILES, C. F.,
GILLIS, H. A.,
GORDON, H. D.,
GORDON, JAS. T.,
GOULD, AMOS,

GRASS, K. J..
GRIFFITH, FRED. B.,

HAINEN, J.,
HALLER, W. J.,
HARDING, B. R.,
HARRISON, W. H.
HATSWELL, T. J.,
HEDLEY, E. M.,
HENDERSON, G. R.,
HICKEY, JOHN,
HIGGINS, S.,
HILL, JAS. W.,
HINMAN, L. M.,
HOLMAN, W. L.,
HUDSON, E. E.,
HUFSMITH, F.,

JONES, W. F.,
JOUGHINS, G. R.,

LAVERY, W.,
LEE, C. W.,
LEEDS, PULASKI,
LEWIS, WM. H.,
LUTTRELL, J. W.,

MACBETH, JAS.,
MACKENZIE, JOHN,
MAGLENN, JAS.,
MANNING, J. H.,
McELVANEY, C. T.,
McGEE, F. H.,
McINTOSH, WM.,
McNAUGHTON, JAS.,
MEDWAY, JOHN,
MILLEN, THOS.,
MILLER, E. H.,
MILLS, STOTT,
MINSHULL, E.,
MINSHULL, P. H.,
MINTO, H. M.,
MITCHELL, A. E.,
MOORE, J. H.,
MURPHY, P. H.,

NAUFFER, JOHN G.,
NOBLE, L. C.,

O'HERIN, WM.,

PATTERSON, J. S.,
PLACE, T. W.,
POTTER, G. S.,
PURVES, T. B., Jr.,

QUAYLE, ROBERT,

RANSON, T. W.,
RETTEW, C. E.,
REYNOLDS, W. W.,
ROBERTS, E. M.,
ROBINSON, JOHN,
ROSS, GEORGE B.,
RYAN, J. J.,

SAGUE, J. E.,
SETCHEL, J. H.,
SHEER, JAS. M.,
SINCLAIR, ANGUS,
SMALL, W. T.,
SMART, C. E.,
SMITH, F. B.,
SMITH, JOHN L.,
SMITH, WM.,
SMITH, W. T.,
SPRAGUE, H. N.,
STALDER, A. W.,
STEVENS, GEO. W.,
STEWART, ANDREW F.,
STEWART, O.,
STINARD, F. A.,
STOUT, HENRY K.,
SUMMERSKILL, T. A.,
SUTHERLAND, R. D.,
SWANSTON, WM.,
SYMONS, W. E.,

TABER, W. G.,
THOMAS, C. F..
THOMAS, H. T.,
THOMAS, J. J., Jr.,

THOMAS, W. H.,
TONGUE, JOHN,
TURNER, CALVIN G.,
TURNER, CHAS. E.,
TYRRELL, THOS. H.,

VAIL, A.,
VAUCLAIN, SAMUEL M.,
VOSS, WM.,

WADE, R. D.,
WAITE, H. M.,
WALKER, C. W.,
WATTS, AMOS H.,
WEISGERBER, E. L.
WELLS, REUBEN,
WEST, G. W.,
WIGHTMAN, D. A.,
WILCOX, W. J.

Associate Members.

BAKER, GEORGE H.,
BARNES, D. L.,
CROSMAN, W. D.,
DEAN, F W.,
HILL, JOHN A.,
MARSHALL, W. H.,
POMEROY, L. R.,
ROBINSON, H. P.,
SMITH, JOHN Y.

Honorary Members.

DIVINE, J. F.,
THOMPSON, JOHN.

Minutes of Last Meeting.

The President—Gentlemen, the next business in order is the acting on the minutes of last meeting. As you are aware, the proceedings have been published, and it has been customary to pass that and to go on to the next order of business. It has been customary merely to accept the report as published.

A Membfr—I move that we accept the report as published.

The motion was carried.

The Secretary's Report.

Secretary Sinclair read his annual report as follows:

At last Convention your secretary reported that there were on the roll 475 active members, 16 associates and 20 honorary members, making a total of 511. At last Convention one active member was transferred to the list of honorary members. Since last year 8 active members, 1 associate and 3 honorary members have died, which takes 12 off the roll, and 53 new members have joined the association. The roll now stands—515 active members, 15 associates and 18 honorary members; a total of 548.

Death has taken from the association some of the oldest and most valuable members. In the list are: N. E. Chapman, one

of the charter members and a past president; L. C. Brastow, Matthew Ellis, H. L. Leach, Basil Manly, John Ortton, David Preston and S. W. Wakefield, all active members. The honorary members taken away are John Black, C. R. Peddle and Isaac Dripps. The latter was the first man in the world to hold the title of superintendent of motive power. The associate whom we have lost was Professor A. T. Woods, a young man who was gaining international reputation as a mechanical engineer.

The annual report was produced in the usual form, 2,000 copies having been printed. This report has been unusually expensive, owing to the large number of engravings and tables, which largely add to the cost of the work. There have been 1,547 copies of the report distributed to the members, to the subscribers to the Printing Fund, to technical and engineering societies and to the press. There has been an unusually active demand for this report by engineering societies abroad, and your secretary has supplied all the requests, most of the reports so sent having been complimentary.

The money collected during the year amounts to $2,747. Of this sum $865 has been received from contributors to the Printing Fund, $1,835 from dues and $47 from sale of reports. The consolidation of railroads is steadily reducing the receipts from railroads to the Printing Fund. Your secretary has lately been in communication with railroad managers on this subject, and there are good prospects that the leading companies will subscribe more liberally in future. Fifteen circulars have been sent out by your secretary during the past year, several of which contained information of value to all railroad men. The circular relating to the standards of the association issued by resolution passed at the last Convention, made an appeal for the more general adherence to standards. It was sent to all the general railroad officers and master mechanics on the North American continent.

The candidates for the benefits of the association's scholarships in the Stevens Institute of Technology were not so numerous as might have been expected, the difficult entrance examination having prevented several who were anxious to obtain a scientific education from entering. The indications are, however, that the candidates will soon exceed the vacancies. A son of Mr. S. A. Hodgman has held a scholarship for the second year with credit

to the association. Two scholars have attended the Stevens Preparatory School, one being a son of Mr. A. J. Cromwell, the other a son of Mr. J. D. McIlwain. These two young men will both enter the Institute in September. This will still leave one scholarship to be filled, and a student may enter either the Institute or the Preparatory School. The splendid engineering education which young men receive in the Stevens Institute of Technology ought to make members ambitious to see their sons enjoy the privilege offered by the association's scholarship.

ANGUS SINCLAIR,
Secretary.

SUBSCRIBERS TO PRINTING FUND.

Baldwin Locomotive Works	$25 00
Baltimore & Ohio	10 00
Boston & Albany	10 00
Brooks Locomotive Works	25 00
Burlington, Cedar Rapids & Northern	10 00
Central Vermont	10 00
Charleston & Savannah	10 00
Chesapeake & Ohio	10 00
Chicago & Alton	10 00
Chicago, Burlington & Northern	10 00
Chicago, Burlington & Quincy	10 00
Chicago & Eastern Illinois	10 00
Chicago & Northwestern	10 00
Chicago, Milwaukee & St. Paul	10 00
Chicago, Rock Island & Pacific	10 00
Chicago, St. Paul, Minneapolis & Omaha	10 00
Cincinnati, Hamilton & Dayton	10 00
Cincinnati, New Orleans & Texas Pacific	10 00
Cleveland, Akron & Columbus	10 00
Cleveland, Cincinnati, Chicago & St. Louis	10 00
Cleveland, Lorain & Wheeling	10 00
Colorado Midland	10 00
Copiapo Railroad	10 00
Concord & Montreal	10 00
Connecticut River	10 00
Delaware & Hudson Canal	10 00

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Rogers Locomotive Works	$50 00
St. Louis & San Francisco	10 00
Savannah, Florida & Western	10 00
Schenectady Locomotive Works	10 00
Southern Pacific	10 00
Terre Haute & Indianapolis	10 00
Toledo & Ohio Central	10 00
Union Pacific	10 00
Western Maryland	10 00
Western New York & Pennsylvania	10 00
Wilmington & Weldon	10 00
Wabash	10 00
	$865 00

Mr. O. STEWART, Treasurer, read the following report:

TREASURER'S REPORT.

In connection with this report a brief statement is necessary. Owing to shortness of funds in the early years of the association, a practice originated of paying the secretary's salary from the receipts of the year succeeding the period in which the work was done. This practice continued to the present year. When the report of last year was submitted it showed a certain large balance on hand, but the secretary's salary had not been paid, and a fictitious balance was always reported. The Executive Committee have determined to change this practice, and show the balance as it exists after all indebtedness is paid. The following report accordingly contains payment of the secretary's salary for two years. This appears to drain our resources closely, yet we have as great a real balance as we ever have had.

Dr.

June, 1892	—To Balance on hand	$1,486 43	
" 1893	—To money received from Secretary Sinclair	2,747 00	
			$4,233 43

Cr.

June, 1892	—*The Saratogian*, printing	$8 00	
	Secretary's salary for 1891–2	1,200 00	
July, "	R. W. Ryan, stenographer's work	156 25	

August, 1892	—Bradley & Poates, engraving.	$208 00		
"	" DeLeeuw, Oppenheimer & Co., printing Annual Report	952 00		
October,	" Insurance on Reports	8 00		
June,	1893—Electrotypes	5 55		
"	" DeLeeuw, Oppenheimer & Co., printing	172 25		
"	" Expressage, postage, telegrams, and other expenses.	149 82		
"	" Secretary's salary, 1892-3	1,200 00		
"	" Bradley & Poates, engraving.	19 28		
			$4,079 15	
	Balance on hand		$154 28	

O. STEWART, *Treasurer.*

DISCUSSION ON REPORTS OF SECRETARY AND TREASURER.

Mr. A. E. MITCHELL—I move that the reports of the secretary and treasurer be accepted and placed on file and printed in the proceedings.

Mr. J. H. SETCHEL—I believe that according to our rules they are to be referred to a committee that is to be elected.

The PRESIDENT—I do not find any rule that requires doing that, Mr. Setchel.

Mr. JOHN MACKENZIE—Mr. Setchel, perhaps, is correct. There is an Auditing Committee for taking care of those accounts, but for the receiving of the report I do not think it is necessary. The motion is simply that the report be accepted and received.

Mr. SETCHEL—That is the point I make. The motion was to receive them and place them on file. That is what I object to, precisely. I suggested that the rules require that the report be referred to the Auditing Committee, which is correct.

Secretary SINCLAIR—In the regular order of business the Auditing Committee will be appointed, and, of course, they take all the books and reports and go through them.

Mr. SETCHEL—Now, Mr. President, I move that the reports of the treasurer and secretary be received and referred to the Auditing Committee.

The PRESIDENT—The motion first made here was that the reports of the secretary ana treasurer be received.

Mr. SETCHEL—Received and placed on file, which, I make the point, is out of order.

The PRESIDENT—The Auditing Committee, Mr. Setchel, as is custom-

Mr. Forsyth—This is rather a long report. I move that the report be accepted as printed without reading, as a preliminary one, and that the committee be continued for further joint action with the committee appointed by the Mechanical Engineers' Society.

The motion was seconded.

Mr. Lewis—I, for one, am opposed to passing a report without reading it. The value of these reports depends largely on the presentation of them at the meetings here, and it opens up discussion which would not take place but for the reading of the reports. I should dislike very much to see that motion prevail.

Mr. S. M. Vauclain—Would the acceptance of the report without reading prevent its discussion? It seems to me that it would require a great deal of time to read this report. If any one wishes to make any remarks it seems to me those remarks might be of use to the committee during the coming year.

The President—The members could read the report at their convenience and set a time for the discussion of it.

Mr. Wm. Forsyth—I would say that this report has been printed for several days, and members have had an opportunity to read it, and it would save considerable time if the reports which were issued in advance were read in advance, so that we could come to the meetings and discuss them intelligently without taking the time to read them.

Mr. F. W. Dean—As a member of the committee on this subject, and the one, I believe, who has done most of the work, I wish to say with reference to a part of Mr. Forsyth's resolution, that I think it is best to regard it as a preliminary report, and to continue the matter and to have a still further conference with the committee of the American Society of Mechanical Engineers, because it is evident that there are some defects in this report, and a recent conference with that committee has shown that there are some points which ought to be touched upon which have not been touched upon; and I should like to say something in regard to the matter of reading this report, but I would like to have it regarded as a preliminary report, and so treated. Mr. Lauder, who is chairman of this committee, I think will bear me out in this, and I think I am authorized to speak for him in this case.

The motion was carried.

The President—If the meeting so desires, they can set a time for taking up and discussing the subject.

Mr. Forsyth—I was rather hoping that the association would either discuss this subject to-day or else appoint a time on Wednesday to discuss it. If they are not so disposed, I should like to occupy a little time in explanation of what has been done by the joint committee of this association and the one from the Mechanical Engineers' Society. Is that in order, Mr. President?

The President—Yes, sir.

Secretary SINCLAIR—A motion would be in order that the discussion of this subject be the first order of business on Wednesday morning.

Mr. FORSYTH—Then I make that as a motion.

The motion was carried.

REPORT ON STANDARD TESTS OF LOCOMOTIVES.

The Committee upon this subject herewith present their report after conference with a similar Committee appointed by the American Society of Mechanical Engineers.

It is of great importance to have a standard method of conducting locomotive tests, especially as the advent of compound locomotives is causing many tests to be made, and the data should be obtained and tabulated in such a way as to render results comparable. Locomotive testing is conducted under such conditions that the methods and precision of stationary engine and boiler tests cannot be used nor realized, but it is desirable to use such discrimination in conducting them that while precise results may not be looked for, such as are valuable for all practicable purposes shall be obtained.

The object of a test may be to ascertain the boiler performance, the valve and cylinder performance, or the general fuel performance per unit of train weight over a unit of distance. While the engineer or the motive power department will require the first two, the management is most interested in the last. In fact, to them the last is the only result of importance. In order to make the data collected complete, and to judge of the amount of power developed which is available to draw the train, a dynamometer car is necessary.

PREPARATION OF LOCOMOTIVES FOR TESTING.

The locomotive to be tested should be in good condition, either new, or thoroughly repaired.

The boiler should be washed out before beginning the trial, the fire side of the tubes cleaned, the exhaust nozzles cleaned and measured, the points of cut-off determined for each notch of the reverse quadrant, the port opening for each notch and the clearances obtained, and the steam gauge tested. In some parts of the country where water is very impure, it may even be necessary to remove the tubes for cleaning in order to have the boiler in proper condition. Even if this is not done, the condition of the tubes

should be ascertained and described. The pistons, slide valves and throttle valves should be tested for tightness, and the degree of leakage, if any, described. All leaks should be stopped if practicable.* The area of the full throttle opening should be ascertained and stated, and a scale should be used on the throttle lever so graduated as to show the proportion that the opening bears to the full opening. The coal and water spaces of the tender should be thoroughly cleaned. Other preparations will be mentioned when dealing with special apparatus.

Instructions should be given to the roundhouse foreman that no repairs nor alterations of any sort be made upon the locomotives without the approval of the person conducting the trial.

The men who operate the engine should not be changed during the trials, and the same methods of running and firing should be preserved.

The run selected must be one on which the same distance is covered each trip, and for comparative tests it is better to make three or more trips with each engine, under like conditions of speed and weight of train. The same cars should be used in each trip.

Through trains, unbroken from end to end of the run, must be selected, and it is desirable, in order to avoid many causes of inaccuracy, to test locomotives when hauling special test trains. It is worthy of note that many railroad companies have been sufficiently liberal to provide such trains.

The Committee desires in this connection to emphasize the importance of eliminating all unusual conditions when testing locomotives, for it is only by so doing that definite conclusions can be formed and satisfaction obtained. If the tests are carried out upon regular trains it is of the greatest importance to adhere to the time table, and in all cases to avoid making up time. In no other way can proper comparisons be drawn between results. If it is desired to test the engine when making faster time than the regular schedule, special trips should be made for this purpose.

The conductor of the trial must be familiar with correct methods of firing and running locomotives, and must insist upon good and uniform methods, and impress the importance of this upon the enginemen throughout the trials.

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* See Appendix for directions for testing tightness of valves and pistons.

He must see that the coal supplied at coaling points is of the proper kind, and must weigh the coal personally, and keep accurate records.

TESTING WITHOUT A DYNAMOMETER CAR.

When the dynamometer car is not used, it is necessary to ascertain the power developed in the cylinders. This can be done by means of the steam-engine indicator. The best methods of applying this instrument, as well as methods of weighing coal and water, will now be described, beginning with

FUEL MEASUREMENTS.

The measurement of fuel in locomotive tests is not difficult so far as a determination of the total amount shovelled into the furnace is concerned. A weighed amount may be placed on the tender, and the amount remaining after a trip weighed and deducted from the original. In case water is used on the coal, a sample of the remaining coal can be dried and a correction made for water. By this method it is impossible to determine the amount used on any particular part of the route, but if the coal is placed in sacks containing 125 lbs. each, with a small amount weighed out on the foot-plate for beginning the trip, it is practicable to open the bags and empty the coal on the foot-plate as it is needed. In this way the rate of consumption can be approximately determined on any part of the trip. To determine the amount of coal used on the whole trip it is only necessary to count the number of bags that have been emptied.

When a locomotive which runs on short trips closely following each other is being tested it may be necessary to keep the terminal fire-level constant, and considerable care is required to do this. In any case, as testing a helping locomotive on a grade, in which one trip quickly follows another there will be occasion for the exercise of this judgment. If the test extends over a period of considerable length, any error in judgment will affect the coal quantity but slightly. It is, however, best to have the opinions of two observers.

The conductor of the trials should enter notes of repairs made on the locomotives tested, and any other events that occur, as

they will assist in explaining many anomalies. He should note as follows:

Dates of trials.
Class of locomotive.
Service in which trials were made, mentioning locality, etc.
Name of conductor of trials.

For each kind of coal he should note:

Kind of coal.
Location of mine.

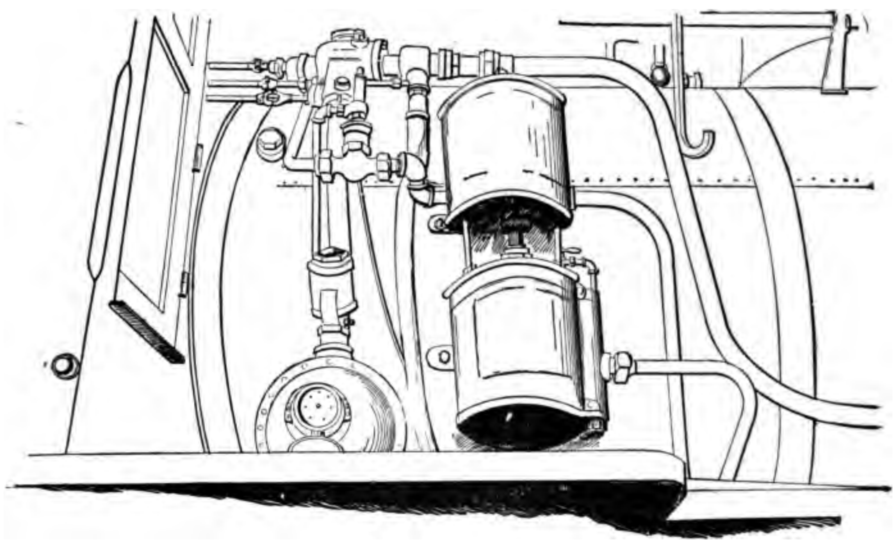

FIG. 1.

Name of mine and operator.
Appearance of coal.
Kind of fire made.
Notes of clinkers and ashes.
Notes of cinders in smokebox.*
Notes of sparks thrown from stack.*
Notes of cleaning ash-pan and smokebox.
The weight of coal consumed.
The weight of ash.
The weight of ash cinders in smokebox.*

* See discussion of this farther on, and its bearing on evaporative results, page 50.

The weight of water evaporated.
The number of cars in the train.
The weight of cars.
The weight of lading.
The number of passengers.
The state of the weather.
The direction of the wind.
The velocity of the wind, if an instrument can be devised for ascertaining this.
The temperature of the atmosphere.
The temperature of the feed-water.
The time on the road.
The time in motion.
The time the throttle-valve is open.
The steam pressure.
The time of passing important stations.
The coal should be analyzed, and its calorific value determined.*

It is important in making a full investigation of the combustion to take sample of the gases in the smokebox for analysis.

If the engineer who conducts the test is unable to analyze the gases a competent chemist should be employed, who will furnish the usual apparatus for extracting samples.

The gas analysis will assist in determining the best method of burning fuel, for thereby he can determine whether the correct quantity of air is admitted to the fire, whether the combustion is complete, and in general whether the fuel has been burned to give the best effect. In this connection, however, it should not be forgotten that, in a locomotive, that method of burning coal which produces the most steam will be regarded as the most efficient.

WATER MEASUREMENTS.

It has been found during the last year or two that meters are reliable and accurate within less than one per cent. for measuring the water used by a locomotive. The meters should be specially made for the purpose and, if possible, free from any material that is injured by contact with hot water. They should be placed so as to be read from the cab. (See Fig. 1.)

* See discussion of this farther on, and its bearing on evaporative results, page 50.

In mounting these meters, all pipes should be thoroughly cleaned before they are put into position, and a sufficiently large strainer should be placed between the meter and the tank. A most essential feature is to have a good check-valve between the injector and the meter; otherwise the hot water may flow backward and ruin the rubber-recording disks in the meter. Meters can now be obtained free from rubber, so that this difficulty is obviated. The check-valve should be used, nevertheless, in order to prevent heating and expansion of the meter and any resultant error. As a check upon the meter, however, other means of

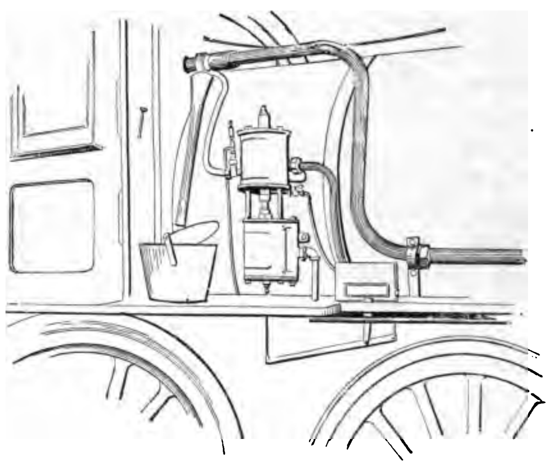

FIG. 2.

measuring the water should be employed. The most convenient method is to use a float attached to a wooden rod which slides upon a graduated rod, the lower end of which rests upon the bottom of the tank. This rod is graduated to show 1,000 pounds, and subdivided to 250 pounds.

The method of graduating the rod is as follows: Fill the tank, place the rod and float in the proper position for reading, and mark the stationary-rod zero at a level with the top of the float-rod. Draw from the tank 1,000 pounds, by drawing 333⅓ pounds into a barrel standing upon the scales, three times. Place the measuring device in position again and mark the rod, calling this mark 1. Again, draw out 1,000 pounds, mark the rod 2, and so

continue until the water is all drawn. If the tank has a uniform horizontal section, several thousand pounds can be drawn off at once, and the rod subdivided accordingly.

The float should be placed in a special opening, made as near the center of gravity of the mean horizontal section of the water space of the tank as possible, for at this point the water will remain at a constant depth with any change of level of the tank.

Another, but less convenient, way is to place a glass tube on each side of the tank opposite the center of gravity of the water space, and to graduate scales behind them by the same method as above described. The objections to this method are the inconvenience of reading the scales (especially at way stations where there is but little time), their liability to freezing in cold weather, and the possibility of injuring them at any time.

The float is always convenient and serviceable.

The waste from the injector should be ascertained by catching it in a vessel conveniently attached (see Fig. 2), or by starting the injector several times in the engine house and catching the overflow in a tub. The total weight of the water caught divided by the number of applications of the injector, gives the average waste. The observer in the cab should keep a record of the number of times the injector is applied during the trips, and thus obtain data for estimating the total waste. This method need only be used with a non-lifting injector. The injectors and check-valves should be in sufficiently good order to prevent any waste from the overflow except in starting.

When locomotive boilers are being fired hard the water rises above the normal level, and a measurement of water just after the injectors have been throwing comparatively cold water into the boiler is not an accurate one; the water shrinks and swells according as the firing is hard or as the locomotive is being worked. Hence, measurements taken under these variable conditions are necessarily approximations. There is also a continuous movement of the water in the water-glass, and a mean of the oscillations is not quite satisfactory. Although the amount of water fed into the boiler can be determined exactly by the use of meters, yet the inaccuracies of the location of the water-line in the boiler render water measurements on short runs almost impracticable. The six-hour test for a stationary engine is considered satisfactory

when successive tests will give the same results; but in locomotive work, unless the engine be kept quiet, as it would be when tested in a shed, a short test is of little or no value. It may be accepted that a determination of the water-line by the sound of the gauge-cocks is too uncertain to be admissible in locomotive tests, unless the run is a long one. In such cases the total amount of water used is so large that any errors in estimating the water level at the beginning or the end of the trip practically disappear, even in tests of not longer than an hour's duration.

A locomotive which is undergoing a test should have a water-glass on the boiler. Behind this should be a piece of wood graduated, and surrounding the glass and fastened to the wood should be a copper wire at the height at which the water should be left at the end of every trip. The tank measurement should not be taken at the end of the trip until the water in the boiler is at the standard height. The temperature of the water should be taken as it enters the tank at every station where water is taken, and tank readings should be taken before and after each filling.

Just before beginning a trip the water in the boiler should be at the standard height and the tank reading taken in order to ascertain the amount of water used while running, or per indicated horse-power per hour.

Extraordinary efforts should be made to prevent blowing off before train time and while running. The number of times and the length of time the safety-valve is blowing off should be recorded.

No water should be taken from the tank for any purpose except supplying the boiler, and the boiler should not be blown off during a test if it can be avoided. If it cannot be avoided, the water should be at the standard height before and after blowing.

Leakage of the Boiler. To test this, keep up as nearly as possible, without blowing off, the pressure to be carried, and note the fall of water in the water-glass in a given time while the engine is not running, say four hours. Of course, the injector must not be applied during this interval. The water meter can then be used to determine the amount lost by leakage by reading the dial, applying the injector until the water reaches the original level, and then taking a second reading. The difference will be the amount of water lost. All boilers lose more or less from this

cause, and if the test is to be a comparison between two different styles, the necessity for this information is obvious.

For the purposes of this coal trial the following form (*A*) should be filled out, after which conclusions as follows should be drawn:

Comparisons of evaporations per pound of coal, both under actual conditions and reduced to the equivalent conditions of "from and at 212°."

Comparisons of coal consumed per car mile and per 100 tons hauled one mile.

Value of coal *A*, 100%.

Value of coal *B*.

Relative value.

Percentage of superiority of one coal over any other.

[FORM A.]

LOCOMOTIVE PERFORMANCE—COAL TRIAL.

TRAINS, NOS. 0 AND 0. BOILER PRESSURE, 000 LBS.

R. R. LOCOMOTIVE CLASS " "

NO. ....

Distance, 000 *Miles*. *Fuel*,.......................................*Coal.*

Between A. & B.

DATE.

Number of Round Trip.	DATE.	Weather.	Temp. of Atmosphere. Average.	Temp. of Feed-Water. Average.	Steam Pressure. Average.	Time on Road. H.	Time on Road. M.	Running Time. H.	Running Time. M.	Av. Running Speed in Miles per Hour.	Number of Cars in Train.	Lbs. Coal Consumed per Trip.	Lbs. Water Evaporated per Trip.	Lbs. Water Evaporated per lb. Coal.	Coal per Car per Mile.	Total Weight of Train in Tons.	Tons Hauled One Mile.	Coal Consumed per 100 Tons per Mile.	REMARKS.
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8																			
9																			
10																			
Totals																			
Averages																			

APPLICATION OF THE INDICATOR.

When making a complete test of a locomotive, or when the power is to be determined, the action of the valve-gear examined, or the coal and water used per unit of power in a unit of time is desired, the indicator must be used. This instrument should be attached to a three-way cock just at the outer edge of the steam-chest, in order that the connecting pipes (which should be ¾ inch in diameter) can go directly in a diagonal direction to holes tapped into the sides of the cylinder rather than into the heads.

By this arrangement the pipes are shorter than when they pass over the steam-chest into the heads, and have but short horizontal portions, thus facilitating rapid draining of the pipes and diminishing condensation.

For the safety of the operator of the indicator it is recommended that the seat be on a piece of boiler-plate above the cylinder, and so arranged that a piston or cylinder-head can pass out without injuring him.

The indicator pipes and three-way cock should be covered with a non-conductor, wrapped with canvas and painted. The indicator itself should be wrapped as high as the vent holes.

The indicator gear should be a true pantagraph motion, either adjustable in height (as shown in Figs. 3 and 4) or rigid (as shown in Fig. 5). The pantagraph should operate a rod which should point directly to the groove in the drum for the cord, and should lie in the plane of that groove. This rod, to which the cord is attached, should extend as closely to the indicator as practicable, in order to make the cord short and thus minimize errors in the diagram due to stretching the cord or from the action of the wind. A cord length of 8 inches is practicable.

The pendulum-reducing mechanism (shown in Fig. 6) should never be used, as it gives too long a cord and requires it to be inclined. The length causes the cord to stretch when running fast, and a diagram taken at 300 revolutions a minute will be fully ⅜ inch longer than one taken at starting, when the normal length is 3 inches. The inclined cord causes it to vibrate transversely when cutting through the wind. This vibration gives an irregular rotation to the drum, and often at high speeds the diagrams bear no resemblance to their proper shape.

The indicator should be so piped that a diagram of the steam-

chest pressure can be made. A steam-gauge on the chest is inaccurate and difficult to use.

Indicator diagrams should be taken at equal distances rather than at equal time intervals, on account of the varying speed of locomotives. If this is not done the power will not be properly averaged, and by doing this no error is introduced by not equally sub-dividing the power as affected by speed. This method reduces

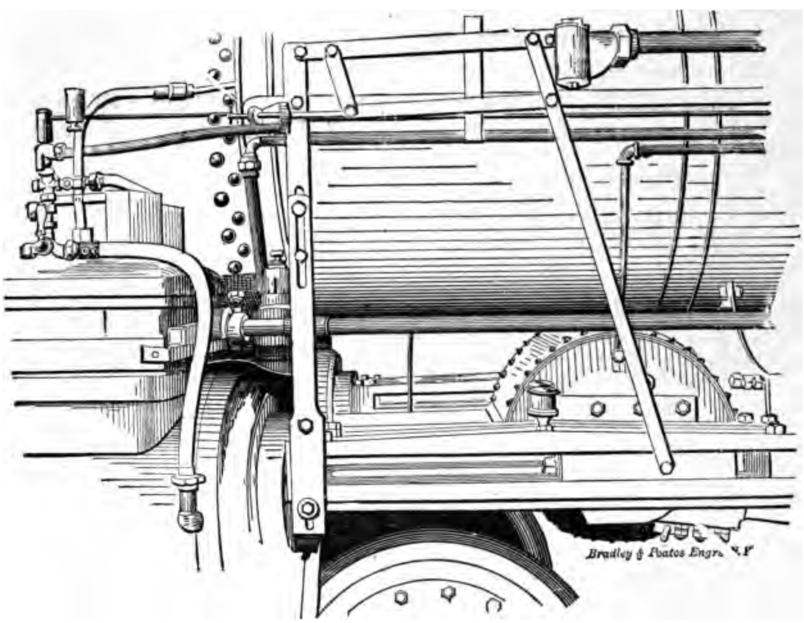

FIG. 3.

the operation to the same level as that of indicating a well regulated stationary engine, where the diagrams are taken after equal numbers of revolutions, and the variation of power is due to the change in mean effective pressure in the cylinder. If this method is not followed, a train which varies its speed may make an enormous number of revolutions, and therefore develop an enormous power, without its being recorded, while if it reduces its speed the low power affects the average too greatly. If the speed is accelerated the frequency of the diagrams is increased, and in proportion to the speed, and therefore a closer record is, so to speak,

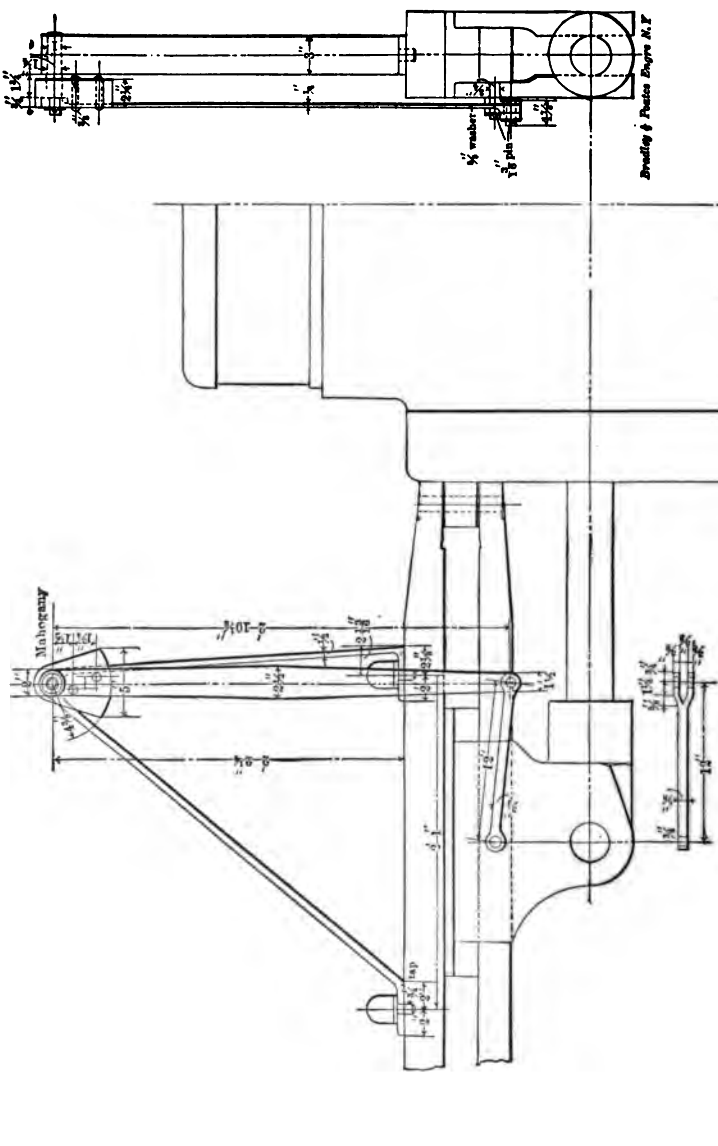

FIG. 6.

The Peabody throttling calorimeter can be used with success upon a locomotive, provided the percentage of moisture is not over five. Recent experiments show that locomotive boilers do not, except temporarily, contain even as much as one per cent. of moisture.

The following is a description of Peabody's throttling calorimeter, taken from his Thermodynamics of the Steam Engine, page 237:

Throttling Calorimeter.—A simple form of calorimeter, shown by Fig. 9, was devised by the author, which depends on the property that dry steam is superheated by throttling. Steam

FIG. 8.

to be tested is brought in by a wrapped pipe *a*, below which the extension *c* with a drip at the end serves as a pocket to catch the water which may gather on the sides of the pipe. The valve at *b* is opened a slight amount to admit steam to the chamber *A*, and the exit-valve at *d* is used to regulate the pressure in the chamber. The temperature in the chamber is taken by a thermometer in a long cup at *e*, and the pressure is taken by the gauge *f*. Let the boiler-pressure be p, and let r and q be the latent heat and heat of the liquid corresponding. Let $p_{,}$ be the pressure in the calorimeter, and $l_{,}$ and $t_{,}$ the total heat and the temperature of saturated steam at that pressure, while t_s is the temperature of the superheated steam in the calorimeter. Then

$$xr+q=l_{,}+c_p(t_s-t_{,});$$

$$x=\frac{l_{,}+c_p(t_s-t_{,})-q}{r} \qquad (285)$$

Example—The following are the data of a test made with this calorimeter:

Pressure of the atmosphere..............	14.8 pounds.
Steam pressure by gauge	69.8 "
Pressure in the calorimeter, gauge.......	12.0 "
Temperature in the calorimeter.........	268.2° F.

$$x = \frac{1156.4 + 0.48\,(268.2 - 243.9) - 286.3}{892.7} = 0.988$$

Per cent. of priming, 1.2

A little consideration shows that this type of calorimeter can

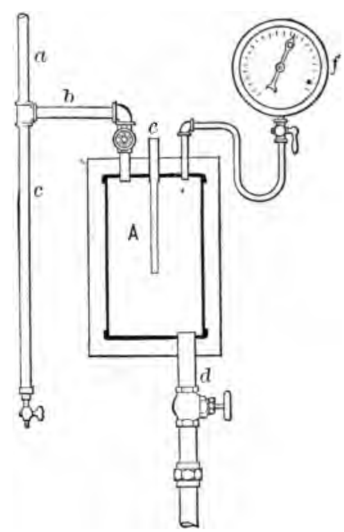

FIG. 9.

be used only when the priming is not excessive; otherwise the wire-drawing will fail to superheat the steam, and in such case nothing can be told about the condition of the steam either before or after wire-drawing. To find this limit for any pressure, t_s may be made equal to t_1, in equation (285); that is, we may assume that the steam is just dry and saturated at that limit in the calorimeter. Ordinarily, the lowest convenient pressure in the calorimeter is the pressure of the atmosphere, or 14.7 pounds to the square inch. The table following has been calculated for

several pressures in the manner indicated. It shows that the limit is higher for higher pressures, but that the calorimeter can be applied only where the priming is moderate:

LIMITS OF THE THROTTLING CALORIMETER.

Pressure.		
Absolute.	Gauge.	Priming.
300	285.3	0.077
250	235.3	0.070
200	185.3	0.061
175	160.3	0.058
150	135.3	0.052
125	110.3	0.046
100	85.3	0.040
75	60.3	0.032
50	35.3	0.023

In case the calorimeter is used near its limit, that is, when the superheating is a few degrees only, it is essential that the thermometer should be entirely reliable, otherwise it might happen that the thermometer would show superheating when the steam in the calorimeter was saturated or moist. In any other case a considerable error in the temperature will produce an inconsiderable effect on the result. Thus, at 100 pounds absolute with atmospheric pressure in the calorimeter, 10° F. of superheating indicates 0.035 priming, and 15° F. indicates 0.032 priming. So, also, a slight error in the gauge-reading has little effect. Suppose the reading to be apparently 100.5 pounds absolute instead of 100, then with 10° of superheating the priming appears to be 0.033 instead of 0.032.

It is often desirable to show temporary priming promptly. For this purpose the calorimeter has been devised which is shown in Fig. 10, and has given satisfaction.

This instrument consists of two pieces of brass pipe one inside of the other, leaving an air space between them. The outer pipe is screwed into the dome and extends close to the throttle in order to be in the most rapid current of the steam. At the inner end the two pipes are joined by a cap having a perforation $\frac{3}{32}$ of an inch in diameter. On the outer end of the inner pipe a globe valve is placed, and next and outside of it there is a tee with a stuffing-box for the insertion of a bare thermometer. Outside of

the tee there is another valve for graduating the flow of the steam. When shutting the outer valve, care should be taken to prevent the thermometer from being blown out of the tee. The whole device should be well wrapped with a good non-conductor of heat, and when so protected can be extended into the cab for convenience in using.

When the boiler foams, both valves being open, the thermometer rapidly drops to 212°, and when the water passes out of the stack this temperature is invariably shown.

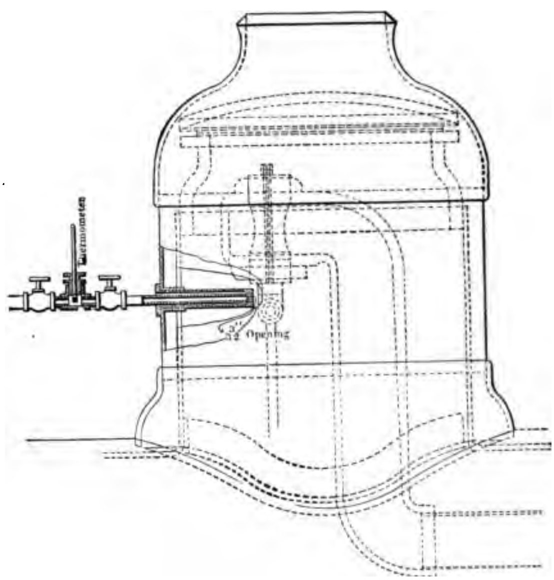

FIG. 10.

By allowing the steam to blow out of the pipe, the temperature of dry saturated steam will be shown and affords means of testing the steam-gauge.

The Peabody calorimeter can be used in the cab, and in order to make it sensitive enough to show temporary priming, the thermometer should be bare, as pointed out by Mr. D. L. Barnes, instead of being inserted in an oil well. The connecting pipe to the boiler should be well clothed, and before taking observations

the steam should be allowed to flow some little time in order to thoroughly heat the apparatus.

Concerning the location of the pipe for drawing the steam for examination, if the condition of the steam as furnished by the boiler is to be tested the position shown in Fig. 10 is correct. If the condition of the steam as it enters the cylinders is to be examined the calorimeter must be used at the front end of the engine and draw its steam from the steam-chest.

The Barrus calorimeter can be used on locomotive tests, and when large quantities of moisture are to be dealt with it is used with a separating apparatus.

Descriptions of the Barrus calorimeter can be found in the "Transactions of the American Society of Mechanical Engineers," Vol. X, page 327; Vol. XI, page 790; Vol. XII, page 825.

Accompanying a report of a test there should be a full table of dimensions and particulars of the locomotive as follows:

BOILER.

Kind of fuel.
Type of boiler.
System of staying crown-sheet.
Height of center above rail.
Diameter inside of smallest ring.
Length of firebox.
Width of firebox.
Length of combustion chamber.
Width of combustion chamber.
Length of grate.
Width of grate.
Outside diameter of tubes.
Length of tubes.
Number of tubes.
Thickness of shell plates.
Thickness of fire plates.
Width of water spaces.
Height of top of stack above rail.
Length of stack.
Smallest inside diameter of stack.
Working steam pressure.

HEATING SURFACE.

Heating surface of inside of tubes.
Heating surface of combustion chamber.
Heating surface of firebox.
Total heating surface.
Grate surface.
Ratio of grate to heating surface.
Total area through tubes.
Ratio area through tubes to grate surface.
Area of least opening in stack.
Ratio of same to grate surface.
Ratio of same to area through tubes.
Size of mesh of netting in smokebox.
Weight of water in boiler at 3 gauges.
Volume in cubic feet of steam space at 3 gauges.
Area of water space at 3 gauges.

CYLINDERS AND VALVE-GEAR.

Type of locomotive.
Diameter of high-pressure cylinder.
Diameter of low-pressure cylinder.
Stroke of high-pressure piston.
Stroke of low-pressure piston.
Diameter of piston-rods.
Cylinder ratio.
Travel of valves in full gear.
Outside lap of valves.
Inside lap or clearance of valves.
Lead in full gear.
Throw of eccentrics.
Notches in quadrant.
Release begins at, in general.
Compression begins at, in general.
Width of steam-ports.
Width of exhaust-port.
Width of bridges.
Number and size of exhaust-nozzles.
High-pressure clearance in per cent. of piston displacement.
Low-pressure clearance in per cent. of piston displacement.
Receiver volume in per cent. of high-pressure piston.

WHEELS AND AXLES, ETC.

Number of driving-wheels.
Diameter of driving-wheels.
Distance from center to center of driving-wheels.
Total driving-wheel base.
Diameter of driving-axles.
Length of driving-axles' journals.
Diameter of crosshead pins.
Length of crosshead pins.
Diameter of main crank-pins.
Length of main crank-pins.
Kind of truck.
Diameter of truck-wheels.
Truck-wheel base.
Diameter of truck-journals.
Length of truck-journals.
Total wheel-base of engine.
Distance of center of main driving-axle to center of cylinders.
Length of connecting-rods.

Tractive force per pound of mean effective pressure per square inch on pistons, reduced to high-pressure cylinder.

Computed by the formula $\frac{d^2s}{D}$ in which

d=diameter of cylinders in inches ;
s=stroke of pistons in inches ;
D=diameter of driving-wheels in inches.

In the case of a compound locomotive the pressure on both pistons may be reduced to an equivalent on one.

TENDER.

Water capacity.
Coal capacity.

WEIGHTS.

On drivers.
On truck.
Total weight of engine in working order.
Total weight of tender in working order.
Total weight of engine and tender in working order.

KINDS OF TESTS.

Reference has been made on the first page of this report to the objects and resulting kinds of tests. When a test is made, all kinds of data should be obtained in order to furnish results to all departments of a railroad company. These will be considered separately.

1st. If it is the custom of a railroad company to keep continuous fires in its locomotives, a test of two weeks' duration should be made under these conditions, weighing the coal and water every day. This is impracticable if the boiler requires frequent blowing off on account of bad water.

2d. If it is customary to drop the fire at the end of every single or round trip, a test of one week's duration under these conditions should be made.

3d. In order to ascertain the actual amount of coal and water used by the locomotive while doing its work, as nearly as possible, separate tests of one day's work should be made, whether on a single or round trip, burning the fire as low as possible on approaching the terminal station, and stopping combustion as completely as possible at intermediate intervals when not at work. The fire should be started as late as possible before train time in order to aid in the accomplishment of the objects of this kind of test. As before recommended, the water should be at the standard level just before the train starts on the trip, and the tank reading taken. The same should be done at the end of the trip. In this way the water used per hour per indicated horse-power can be determined.

By this method tests can be conducted by a uniform method throughout the country for purposes of comparison of locomotives with each other, and with stationary engines and boilers.

FINAL BASIS OF COMPARISON WHEN A DYNAMOMETER IS NOT USED.

As a practical and commercial unit for comparison the determination of amount of coal used per ton-mile is recommended.

As a unit for comparison of boilers the determination of the total heat received by the water in the boiler from a pound of coal is necessary when the same kind of coal is used.

When different coals are used the determination of the total heat derived from a pound of combustible is necessary.*

* See discussion of this, page 50.

As final units for comparison the number of pounds of coal used per hour per horse-power and the efficiency of the locomotive as per Item 22, Form D, should be determined.

As final units for comparison of cylinder performance, the number of heat units used per minute per horse-power and the efficiency as per Item 19, Form D, should be determined.

TABULATION OF RESULTS.

For the tabulation of the general results of a test, Form B should be used.

For the tabulation of the cylinder performance, Form C should be used.

For the tabulation of efficiencies, Form D should be used.

[FORM B.]

LOCOMOTIVE TESTS.

GENERAL RESULTS.

....*Railroad Co.*

................*Tests of Locomotive No.* ...., *between*................*and*........................

....

....*Bound.* ...., *18* ....

Distance, ...*Miles.* *Train No.* ....

Kind of Coal........................ *Coal Analysis*........................

Calorimetric Value of Coal................ ....

	Trip No.						
	Date						
	Left .... at						
	Arrived .... "						
	Left .... "						
	Arrived .... "						
1	Weather						
2	Mean temperature of atmosphere						
3	Direction of wind						
4	Velocity of wind, miles per hour						
5	Condition of rail						
6	Size of exhaust-nozzle, single or double						
7	Weight of train in tons of 2,000 lbs., including lccomotive, tender, passengers, and freight						
8	Weight of train in tons of 2,000 lbs., excluding the locomotive and tender						
9	Equivalent number of standard cars at tons each						
10	Maximum boiler pressure by gauge						
11	Minimum " "						
12	Average " "						
13	Prevailing position of throttle						
14	" " reverse lever						
15	" points of cut-off						
16	Schedule time in motion						
17	Actual " "						
18	Time made up in minutes						
19	Aggregate intermediate stops, minutes						
20	Time during which power was developed, or throttle open						
21	Average speed, miles per hour						
22	Maximum number of revolutions per minute						
23	" rate of speed, miles per hour						
24	Minimum number of seconds per mile						
25	Actual weight of coal used						
26	" wood						
27	Average weight of coal burned per sq. foot of grate per hour						
28	Number of miles run per ton (2,000 lbs.) of coal						
29	Number of pounds of coal used per mile						
30	Weight of ashes and uncons'med coal in firebox and ash-pan						
31	" unconsumed coal in firebox and ash-pan						
32	" cinders (sparks) in smokebox						
33	" combustible utilized						
34	Percentage of ashes and unconsumed coal in firebox and ash-pan						
35	Percentage of unconsumed coal in firebox and ash-pan						
36	" cinders in smokebox						
37	" combustible consumed						
38	Average temperature of feed water						
39	Weight of water drawn from tender						
40	Waste of injector						
41	Weight of water evaporated (39-40)						
42	Actual evaporation per pound of total coal						
43	Equivalent evaporation from and at 212° per pound of coal						
44	" " " " combustible						
45	Coal used per ton of train per 100 miles						
46	" " car mile						
47	Water used per ton of train per 100 miles						
48	" " car mile						
49	" " hour while developing power						
50	" " " per square foot of heating surface						
51	" " " " " grate "						
52	Maximum indicated horse-power developed						
53	Average " " "						
54	Total coal per indicated horse-power developed per hour						
55	Water evaporated per indicated horse-power per hour						
56	Dry steam used per indicated horse-power per hour, per indicator diagram						
57	Percentage of moisture in steam						
58	Average number of square feet of heating surface per indicated horse-power						
59	Average number of indicated horse-power per square foot of grate surface						
60	Average temperature in smokebox while using steam						
61	Prevailing vacuum " " "						

..........Bound. [Form C.] ....189..........

Dimensions.

RESULTS OF INDICATOR TESTS OF LOCOMOTIVE No. ....

.... *Railroad Co.*

CYLINDER PERFORMANCE.

									Points of Cut-off.				Pressures.						Pressures.				Pressures.				Indicated Horse Powers.				Fuel and Water Consumptions.						
1	2	3	4		5		6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36
Dia'ter.			Cards.		Mile Posts.																																
H. P. Cyl.	L. P. Cyl.	Stroke of Piston.	No.	Time.	No.	Time.	Revs. per Minute.	Piston Speed, Feet per Minute.	H. P. Inches of Stroke.	H. P. per cent. of Stroke.	L. P. Inches of Stroke.	L. P. per cent. of Stroke.	Boiler Gauge.	Left or H. P. Steam Chest.	Left or H. P. Cyl. Initial.	Left or H. P. Cyl. Least Back.	Left or H. P. Cyl. Back at Mid-Stroke.	Pressure in Receiver.	Right or L. P. Cyl. Steam Chest.	Right or L. P. Cyl. Initial.	Right or L. P. Cyl. Least Back.	Right or L. P. Cyl. Back at Mid-Stroke.	Left or H. P. Cyl. Mean Effective Front.	Left or H. P. Cyl. Mean Effective Back.	Right or L. P. Cyl. Mean Effective Front.	Right or L. P. Cyl. Mean Effective Back.	Left or H. P. Cyl.	Right or L. P. Cyl.	Total.	Difference between H. P. and L. P.	Fuel per I. H. P. per Hour.	Water per I. H. P. per Hour.	Steam accounted for by Indicator at Release, per I. H. P. per Hour.	Percentage of 32 to 31.			

FORM D.

Table of Efficiencies.

1. Coal used per ton-mile.
2. Water " "
3. " evaporated per pound of coal from and at 212°.
4. " " " " combustible and at 212°.*
5. Coal used per hour per indicated horse-power.
6. Combustible " " "
7. Dry steam " " "
8. Total heat derived from a pound of coal in British thermal units.
9. Total heat derived from a pound of combustible B. T. U.
10. Thermal value of one pound of coal by analysis B. T. U.
11. Thermal value of one pound of coal by calorimeter experiment B. T. U.
12. Efficiency of boiler (Item 8 ÷ Item 11).
13. Thermal units imparted to each pound of steam used from average temperature of feed at average steam pressure B. T. U.
14. Total heat supplied by boiler to cylinders per hour B. T. U.
15. Total heat supplied by boiler to cylinders per minute per indicated horse-power B. T. U.
16. Mechanical equivalent of a British unit of heat (Rowland), 778 feet-pounds.
17. Mechanical value of one horse-power per minute, 33,000 feet-pounds.
18. Mechanical value of Item 15 (15th Item × 778), feet-pounds.
19. Efficiency of valve-gear and cylinders (Item 17 ÷ Item 18).
20. Thermal value of coal used per minute per horse-power (derived from Items 5 and 11) B. T. U.
21. Mechanical value of Item 20 (20th Item × 778), feet-pounds.
22. Efficiency of locomotive (Item 17 ÷ Item 21).

In computing the amount of steam used per unit of time per horse-power, the actual weight of water fed to boiler should be used.† The moisture in the steam may be deducted with propriety.

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* See discussion, page 50.

† This caution seems to be necessary in view of the fact that the fundamental error of using the amount reduced to the equivalent from and at 212° is frequently committed.

Reference has several times been made to the accumulation of cinders in the smokebox, and to evaporation per pound of combustible. If a locomotive exhaust has a severe action upon the fire, as is the case with most simple and some compound engines, a great many cinders are thrown from the stack. This is particularly the case if the trip is long enough to fill up the smokebox, after which all cinders are expelled. It is thus evident that in subtracting from the weight of coal used the weight of cinders and ashes, in order to obtain the weight of combustible, too little is subtracted, and too much combustible is obtained. The evaporation per pound of combustible is therefore fictitious and too small. The effect of this is not only to produce error, but to give a relatively worse showing for the engine that throws most sparks. If, therefore, evaporation is to be based upon combustible, it is best to estimate the amount of combustible from the calorimetric examination of the coal, for all residue left in the apparatus can be considered as non-combustible.

DYNAMOMETER RECORDS.

The dynamometer for measuring the resistance of the train, exclusive of the engine and tender resistance, should be able to record the following data :

A—The pull upon the draw-bar.

B—The speed at which the train is running.

C—The location of any point along the line used for reference stations.

A—The Pull upon the Draw-bar.

The force required to move the train, or the pull upon the draw bar, should be registered upon a strip of paper traveling at a definite rate per mile of distance traveled over by the train ; the scale upon which this diagram is drawn should be as large as is possible within any reasonable limits ; a scale of ¼ inch per 1,000 pounds pull is probably as suitable as any that can be devised, and the maximum registered pull need hardly exceed 28,000 or 30,000 pounds ; the height of the diagram should be measured from a base line drawn upon the paper by a stationary pen so located that when no force is exerted upon the draw-bar the base line should coincide with zero pull.

B—The Speed at which the Train is Running.

This record should, if possible, be obtained in two ways:

First. By an accurate timepiece, preferably a chronometer furnished with an electric circuit-breaking device. It is of considerable importance that the timepiece should have its circuit-breaking device very carefully made, to produce exact intervals of time marks, because, when the matters of acceleration or retardation of speeds enter into the data required, it is important that the time record should be correct. The question of length of intervals of time required is open for discussion. In most cases of ordinary work, five seconds intervals, or twelve to the minute, is probably as satisfactory as can be decided upon; for very careful work it would probably be advisable to have an auxiliary apparatus, something like the Boyer Speed Recorder.

Boyer Speed Recorder Diagram.—Its accuracy and reliability is without question when the device is properly mounted and cared for. It is not a delicate machine, and only needs ordinary attention. Its operation is well known to most of our members. It consists of an oil pump which works against a fixed resistance in the shape of an aperture through which the oil flows. The faster the pump runs the greater is the pressure in the oil cylinder. A piston in the oil cylinder, which moves against a spring, rises in proportion to the increase of pressure. As the piston rises, a metallic pencil marks the movement on a roll of prepared paper, which moves in proportion to the longitudinal movement of the engine. In the cab is a dial which indicates at all times the speed of the engine with only a small error. The diagrams record all stops and make an accurate record of the rate of acceleration.

Second. It would be very desirable to have, in addition to the apparatus just described, another one which produces a continuous curve upon the diagram paper, the ordinates of which, measured from a base line, would give the speed in feet per second, or any other convenient measurement; this could be obtained by modification of the Boyer Speed Indicator.

C—The Location of Any Point Along the Line Used for Reference Stations.

These location marks are most easily produced by having, at various convenient parts of the car, electric press buttons, and

having a pen upon the dynamometer, which will be deflected sidewise when the circuit is made or broken; this pen to be operated by an observer whose special duty is to attend to this part of the work.

GENERAL.

It is of very great advantage to have more than one relative speed on the paper upon which the diagrams are recorded, and the length of the paper consumed per mile run should bear some convenient relation to the distance traveled over.

We would suggest that the rates of travel of paper per mile be such that one inch measured upon the diagrams represents 100 feet as the maximum, and that this distance be further subdivided so that one-half inch would represent 100 feet of track, and one-quarter inch would represent 100 feet of track. It is, of course, also necessary to have all of the registering pens located upon one line transverse to the direction of the movement of the paper, as in that way only can simultaneous data be recorded.

The staff required to work the dynamometer is as follows:

One chief, who has general supervision over the force and whose duty is to see that the records are properly obtained, and that all the location stations are properly marked upon the diagrams.

One look-out, whose duty is solely to observe the location of stations and to locate them upon the diagrams by means of an electrically moved pen.

Besides this it is of considerable advantage to have a third person who is familiar with all the mechanism in the car, and who looks after the proper working of the mechanical parts of the apparatus, and assists the general observer.

APPENDIX.

Leakage Tests of Valves and Pistons.

It is of the greatest importance in analyzing the results of a locomotive test to have definite knowledge in regard to the tightness of the valves and pistons. If leakages are known to exist, an explanation is often furnished of results which would otherwise appear inconsistent. The tightness of the pistons and valves

cannot be determined under the working conditions of a running engine, but there is excellent ground for the belief that if an engine is found to be tight when tested at rest, it will be tight when in action ; and on the other hand, that if it is found to be leaking when at rest, it will likewise leak to a greater or less extent when at work. At all events, the engine should be tested for leakage when at rest, and such information determined as this trial will give, so as to furnish some guide as to the condition of the engine in this important matter.

In a simple engine the steam-valve can be tested by setting the engine so that the valve on one side will be at the center of its throw, in which position both ports are usually covered, and pulling open the throttle-valve, blocking the drivers if the other side takes a sufficient amount of steam to set the engine in motion. Leakage of the valve, if any occurs, will show itself by escaping at the smokestack or open drain-cocks. In the simple engine also the tightness of the piston may be tested by setting the engine so that it takes steam, blocking the drivers, and pulling open the throttle-valve. This should be tried first on one cylinder and then on the other, and if desired it may be tried with the pistons at various points in the stroke. The leakage, if any occurs, will be shown at the top of the smokestack.

In the compound engine, leakage of the valve of the high-pressure cylinder can be made to appear by opening the indicator cocks or drain-cocks of that cylinder when the valve is placed at mid-throw and full boiler pressure is admitted to the steam-chest. The leakage of the valve of the low-pressure cylinder will reveal itself by escaping at the smokestack, or at the open drain-cocks. Leakage of the piston of the high-pressure cylinder can be made to escape at the open indicator cock or drain-cock of the low-pressure cylinder at the proper end, and leakage of the low-pressure piston will be revealed at the smokestack.

J. N. LAUDER,
W. J. ROBERTSON,
ALBERT GRIGGS,
JOHN D. CAMPBELL,
F. W. DEAN,

Committee.

Noon-Hour Discussions.

The President—Gentlemen, we have now reached the noon-hour, at which time it has been our custom to take up topical questions and discuss them. We have one subject here that the secretary will read.

Secretary Sinclair—If any other gentlemen have subjects that they wish to hear the views of the members on they should hand a slip to me as soon as possible. There is one subject handed in:

Method of Fluting Side-Rods.

"Should the Fluting on the Side-Rods Be Done at the Forge under the Steam Hammer, or in the Machine Shop on the Planing Machine?"

It is introduced by Mr. J. Davis Barnett.

Mr. Barnett—This is a practical question of shop practice, and as we have been manufacturing fluting—you understand by fluting the double channel-rod—as we have been manufacturing fluted rods both ways, I ought to be able to answer my own question. But there are several points that came up in the last year in the matter which I should like to put as questions to you, to see if I can get any more information than that which I possess at the present moment. Undoubtedly you can manufacture your rod more cheaply by forging the flutes. And if the milling machines and planing machines should be fairly well occupied on other work, it sometimes seems a clear gain to do that work under the hammer, and thereby relieve those tools in machine shops. The questions that I wish .o put are: Has any person here any practical knowledge whereby he could say if a fluted rod is any stronger or more serviceable by reason of being left with the skin on? Another form is: If the rod is machined and left bright does its treatment tend to show any defects that might be in the rod? Is there any value in machining and manufacturing in a more expensive way, because in planing out you might discover hidden defects in the metal out of which the rod is forged? If machined and left bright, is it any easier to discover the incipient flaws and defects before they develop than it is in the case of a forged rod that is painted and turned out as a painted piece of work? As a matter of shop practice, have any of the members tried steel dies for the hammer and found that they gave better results than cast-iron dies? If they have used steel dies, were the steel dies cast or forged, and did they use any large amount of water in doing the work? Because there is a possibility, in cast steel, if you use too much water under the hammer, of hardening the surface of your die and causing very early failure. Another point of shop practice: Is it cheaper or better to finish the ends? Because in most cases the ends of fluted rods are made to fit the bush brass. In finishing those ends is it better to swedge them to shape or stamp them out in dies? What I mean by swedging is bringing the form on the top of the end of the rod that just forms it into shape. In the case of a die, you hollow out the metal and force the end of your rod bodily into the die. In giving a synopsis of the whole, I would say that my personal experi-

ence is that the forging is a success, and can be done cheaper than the machining. The question upon which I am asking information first is: Is a forged rod of exactly the same section as a mechanical rod any stronger? Question No. 2: Is a bright rod, machined and left bright, any safer because of the opportunity of discovering hidden flaws? Question No. 3: Has any person present any valuable experience as to the material to be used for steam hammered dies or swedges? (Applause.)

Mr. S. M. VAUCLAIN—We make about thirty-five million pounds of forgings a year, and I would not want to be put on record as saying that a forging to meet the size was as strong made of steel as one that had been made above size and finished. I suppose that you are all users of steel axles, and the use of steel axles has brought out the specification that the axle must be turned all over. It is not turned all over without reason or without good cause. It is turned all over to determine whether there are any slight surface defects, and if there are, that they may be removed, and a slight turning will remove them. They are also turned all over to make them of uniform section, so as to thoroughly distribute the strain throughout the axle. It seems to me that a fluted rod, if it is made of I-section, should be made of uniform section, unless the section could be increased in the center. That is, the fluting should be of uniform size throughout, but the depth of the rod might be increased in the center, as is practiced by some railroads, and more noticeably on railroads in France. The idea of forging a fluted rod under the hammer in a smith's shop and making it less expensive than on milling machines, it seems to me, cannot be borne out, provided you have all the work you can do on your hammers and all the work you can do on your milling machines. If a rod had to be fluted under the hammer we would not only have to pay a larger number of men for performing the operation, but we would have to fire the furnaces as well, and then we would not get as desirable results. I have yet to find a forgeman who could forge a good steel rod of exactly uniform dimensions throughout. The least variation in the blow would make a variation in the thickness of the rod. You are liable to drive splinters or other defects into the surface of the rods, and conceal them by the skin that you put on by your method of forging. I am of the opinion that fluted rods should be milled on a milling machine, so that we would be sure that no defects whatever exist in the steel or the billet of steel from which that rod had been forged. (Applause.)

Mr. F. W. DEAN—One point touched upon by Mr. Barnett is rather interesting, and that is whether or not a forging is stronger that has not been finished in a machine, on the outside, than one that has been finished. I recollect seeing a number of conclusions to which Mr. Kirkaldy of London had arrived, and he is celebrated as making a great many tests of all sorts of materials. I recollect one of his conclusions read something like this: "The prevailing idea that the skin of a forging is stronger than the inside is erroneous." Elsewhere he states that this is true of cast iron. That is the prevailing opinion and it is the correct one, to the best of my belief.

But for anything that is forged, his conclusion is that the inside is just as good as the outside. If that is true, of course it is just as well, so far as the strength is concerned, to finish the rod as not.

Mr. D. L. BARNES—I believe Mr. Kirkaldy's experiments were based on a shaft about twenty inches in diameter, forged with a big hammer. This whole question depends on the size of the hammer that does the work. If it is a light hammer. the skin of the material is very much condensed and made ductile. If it is a heavy hammer, it is treated very much the same throughout.

Mr. VAUCLAIN—In regard to the skin of a forging; if the skin of a forging were perfect, if there were no indentations in it whatever, it might be stronger. We have no evidence that the skin of a forging is any stronger than the interior of a forging, if the forging is made of the proper material. But my opinion is, from the experience I have had, that the skin of a forging is weaker than the interior of a forging, on account of its being full of slight indentations that even with the utmost care it is impossible to keep out. I might say, in connection with this matter, that it is desirable to have a proper amount of work put on the steel before the steel is used for forging. It happened in my experience to find out in purchasing steel blooms for specification which called for a piece of the bloom to carry a certain tensile strength and elongation, cut from the bloom and hammered under a hammer, that we could get a great many different qualities of steel that would fill the specification. We found that ingots cast 12, 14, 16 and 24 inches would all show practically the same results—pieces cut and hammered down to a square inch under a hammer and then tested. We found that to obtain a uniform quality of steel for forgings it was necessary to make our specifications read—a test piece cut from the billet must stand a certain tensile strength and a certain elongation. This necessitated the casting of larger ingots and the work being put on them in the steel mill before the billet was sold to us.

Mr. H. A. GILLIS—Several years ago, when on the Chicago & Alton, I saw—I think it was at Bloomington—that rods were being forged as Mr. Barnett describes. I do not know what the results were, but I thought if there was anyone here from the Chicago & Alton he might give us some very valuable information, as they practiced that method of forging.

Mr. FORSYTH—We have been forging rods at our Burlington shops quite a while, and we think they are very nice rods. We do not do it, however, because we think that the rod is better than one which is finished, but simply as a matter of economy, and only for use on freight and second-class engines.

Mr. BARNETT—As I understand Mr. Vauclain to say that the Baldwin's experiences were similar to my own experiences with wrought-iron scrap, I would like to ask Mr. Forsyth if his experience is with steel or with wrought-iron scrap?

Mr. FORSYTH—It is with each of them. We have made quite a lot out of steel.

Mr. L. R. Pomeroy—Speaking relative to the Alton practice, during Mr. Wilson's time, he used to forge almost all of the rods, and he used two sets of dies, one for the rough and one for the finished forging, so that the result from the finishing die was a very smooth piece of forging. But when they compared the cost with putting either through a planer or milling machine; it cost materially more on that account.

Mr. G. R. Henderson—I understood Mr. Vauclain to say that they had to revise their specifications for steel billets so as to have the test piece cut right out of the billet instead of being drawn out. I would like to ask if that does not consume a great deal of material?

Mr. Vauclain—Mr. Henderson is right. It consumes a great deal of material. But we know what we are doing. In the other way we consume very little material, but we know nothing about what we are doing after we get through. We simply had a parallel case with all blooms, no matter where we bought them. They all tested about the same as long as the piece was hammered down under a hammer to inch square. I might say that we had steel blooms which had high tensile strength, and the elongation was not much over 5 per cent. But now our steel blooms show the percentage of elongation that we desire in our forgings, and we are able to meet any specification by simply referring to the hot bar, and taking the billet that would meet that specification. We find that making the forging from such a billet gives us very little loss—not over 3.000 pounds.

Mr. Pomeroy—I would like to ask Mr. Barnett if they finish the rod from one set of dies under the hammer? When I saw them making them at Montreal it was simply after that manner. That is where they differ from the Alton method.

Mr. Barnett—I have finished from the one die, but believe that a showier piece of work could be turned out by the use of two dies. But I would be quite willing to submit with pride the kind of work turned out from the one set of dies to the observation of any master mechanic present in this room. In the matter of cost, the first two or three rods do run up expensive. It is difficult to find a forgeman who will at once forge a fluted rod. Practically, that man has to gain his experience on the first four or six pairs of rods at the expense of the railway companies, and most of you, I imagine, if you go through your experience, will not be particularly proud of the first few sets your green man turns out. But after a little practice on the part of that man the result is eminently satisfactory with one pair of dies.

Mr. Pulaski Leeds—I believe it is an axiom among mechanics that what is right looks right, and I think that a forging that is worked up true and nice will undoubtedly stand more strain than one that is full of dents, etc. I think that in forging the ends they are swedged so that the fibers of the iron turn around the crown of the boss, and that they are apt to get a great deal stronger job than where they just take a flat piece and slab it on. At the same time I do not see why we are not getting a great deal of benefit from the forged rod, as far as the working material is concerned, in the

body of the rod. In the first place, we leave the skin where the strength is needed; that in the milling on the top and bottom of the rod, either on the sides, top or bottom where the strain comes, we only barely skin it off. In the next place. I have found that in forging of all kinds where we forge up to a square corner we are very apt to have little fine cracks there. If that corner is machined off it leaves us good solid material; while if we undertake to work it down, we have simply covered a lot of little cracks that exist there. I found that particularly so in steel that I have undertaken to work up from the billet, and I think that there is very little preference in the strength of a machined rod or of a forged rod, except, perhaps, right in the stub end itself; and that simply from the turning of the crown around the boss, the same as though you punched a hole and swelled it up instead of right straight across. I have had a good many knuckle joints break from the very reason that they were slabbed out, while I never did have one break that was forged so as to carry the crown of the iron. With steel I do not suppose that would hold good.

Mr. A. E. Mitchell—We flute all our rods on the milling machine. I believe that is the best practice. We use entirely steel rods.

Mr. Wm. H. Lewis—I quite agree with what Mr. Vauclain says about the value of the skin of the metal. We all know that in forging, the forging presents the appearance of little spider-web cracks that smiths generally term fire-cracks, and these incipient cracks are simply the starting-point of a fracture which will occur from the vibrations of the rod. If there is a little crack present on the surface of the rod it is simply a starting-point for the rod breaking or the crack extending. I have no doubt that nearly all the gentlemen present have in their experience at some time discovered a little crack in a side-rod which they have watched carefully from time to time and have seen it extend until in their judgment it had reached the limit of safety, and the rod has been removed on that account. The machining or milling of the rod will remove all those surface cracks, and while it may cost a little more than the forging, I think it is money well expended and that the rod should be milled on all of its surfaces.

Mr. Geo. L. Potter—It is our practice to finish fluted rods all over. I think it is necessary, for the reason that it will remove any small cracks or indentations that might exist and which would be a starting-point for a fracture. I would state, however, that our fluted rods are all made of steel.

Mr. Henderson—I think Mr. Barnett stated that he made his side-rods out of iron entirely. I would like to know if he has any preference for iron over steel for that reason, or whether it is merely because he happens to have the scrap on hand.

Mr. Barnett—The reason is simply because we have the iron scrap. We would have to sell it otherwise. I have no experience in steel. We make the rod out of wrought iron, and though fluted, no lighter in dead weight than the old-fashioned slab rod. We always use the very deep rod tapering from 1⅛-inch thickness at one end to 1⅜-inch thickness at the center. That rod weighs just about what the fluted rod weighs. So far

as I know, we have made no experiments with steel in any of our workshops for either side or connecting rods.

Mr. J. H. SETCHEL—It seems to me that both sides of this question have been very fairly stated. I agree, however, with Mr. Lewis and Mr. Vauclain in this matter. I think that in order to equalize all the strains that are unavoidable in a forging of any kind it is necessary that the surface should be taken off. You cannot forge an I-beam rod, you cannot forge a shape of that kind, and have the strains regular. As Mr. Vauclain has said, an extra blow or an extra pressure makes a difference in the thickness of the rod that is not discovered, and planing or milling it will take it out. It seems to me essential that the I-beam rod should be milled. The question occurred to me while this matter was being talked of, though it is not exactly in the line except as to the effect of the skin, and that is the turning of tires. I think it is the practice of a great many excellent master mechanics not to turn their tires. Now, it seems to me that a steel tire is full of those little cracks that form a starting-point for a break. It is impossible to get a tire so regular that it will run so smooth, wear so regular, without turning, as it will otherwise, and I am a great believer in the turning of tires.

Mr. WILLIAM SMITH—We have very little experience with fluted rods. We have only about ten or twelve sets on. I was at the Alton shops about two or three weeks ago, and, as Mr. Pomeroy says, I saw the dies that they used for making their rods were steel dies, and they have two sets. I examined the rods afterwards and they seemed to me to be very perfect. I would have no hesitation in using those rods, inasmuch as they are just as good as milled rods. There is an objection to the variation in thickness, with the hammer, that there is not in the milling.

Secretary SINCLAIR—I have paid a great deal of attention to this subject in my visits to the various shops, especially where fluting of the rods was followed under the hammer. I believe that Mr. Wilson, of the Chicago & Alton, was the first to begin it. But it is practiced in a great many other shops now. I never heard, however, that there was any preference for a rod finished in that way, except on account of cheapness. They considered that it was much cheaper to do the work that way, than to begin milling it and then finish it under the planer Since milling machines were made that were capable of milling the flute entirely, without planing, I think the work can be done that way cheaper than it can be done under the hammer, and I expect that working them out under the hammer will only continue until the shops doing it are rich enough to buy milling machines strong enough to do the work.

Mr. POMEROY—On our way home from the Convention at Old Point Comfort, the superintendent of motive power of the Alton was discussing the matter with a representative of one of the large locomotive concerns, and they went in detail over their method of practice, and it was the conclusion reached by the gentleman who represented the locomotive concern, who had forged them and had planed them, that it was a great deal

cheaper to finish the rods from the milling machine. In fact, it seems to me, it is in the neighborhood of 35 per cent. cheaper, as he expressed it, and he had figures to support what he said. That is, having a miller that would cut clean from end to end.

Mr. WILLIAM SMITH--The trouble in a great many shops is that they have not got the milling machines to mill them out with. We have no milling machine that would mill them out in the proper time. I could make them cheaper under the die than I could under the milling machine we have in our shop. Of course, Mr. Vauclain probably has milling machines that could finish in a quarter of the time that we could. We have to work to suit ourselves to circumstances.

Mr. VAUCLAIN—In regard to the cost of manufacturing fluted rods under the hammer and on the milling machine, fluted rods can be made for about 25 per cent. at our works of what it would cost to make them under the hammer. In addition to that there is another element that enters, and that is, whether we employ skilled labor or unskilled labor. If we have an experienced hammer man, should he stay out, as that class of men sometimes do, we would have to wait until he came back to get some more fluted rods. But if we do the work on the milling machine we not only get it done better, but if the milling man goes out we put on another man to run the milling machine. We believe that the day of the blacksmith shop has passed, that the mechanic is going to be the blacksmith. About seven years ago we had some four acres of blacksmith shop and we built ten locomotives a week, of very light weight compared with the locomotives that we build to-day; while at the present time we have two acres of blacksmith shop and we build twenty locomotives a week.

Mr. SMITH—I think most of the railroad people here will say that we cannot control our employés as the Baldwin works and other Eastern manufacturing concerns can control theirs. They have mechanics developed through three or four generations. We cannot get a man that will run two machines. They can get a man that will run three or four machines, and, of course, their work is done much cheaper than ours.

Mr. F. W. DEAN—There is one point here that has not been touched on, and that is, improvement in milling machines. I had my attention called recently to a machine made by the Pratt & Whitney Company that rather revolutionizes practice in that respect. The old way has been to run the milling machine so that the cutting edge moves in the opposite direction to the movement of the rod. But they now make the machine so that the cutting edge moves in the same direction, so that the action of the milling machine is to pull the rod under, and the success of that method, they inform me, depends on the weight of the milling machine. The ordinary idea is that the tool would tend to pull the rod under the machine and tear it all to pieces. That seems to be a question of the amount of metal in the machine, and they inform me that the work could be very much more readily done with the new method than with the old.

The PRESIDENT—If you do not desire to say anything more on this subject, a motion to close the discussion will be in order.

Secretary SINCLAIR—I move that the discussion be closed.

The motion was carried.

DISCUSSION ON BROKEN CYLINDERS.

Secretary SINCLAIR—Mr. Gentry has presented this question:

"Has any Member Using Heavy Consolidation Engines Had Trouble with Broken Cylinders and Frames; also Cylinders Getting Loose, etc.?"

Mr. GENTRY—Mr. President, I referred particularly to consolidation engines with fireboxes on top of the frames, necessitating very long saddles. We have had and are still having considerable trouble from our cylinders breaking off at the saddle, right next to the frame. We have had them leave our engine house without a crack that we could discover, and before running sixty miles we had the cylinder break bodily right off, while the engine was in very fair shape in every other way. There was no unusual thump in the rods. It was in very fair order. We found it also very hard to keep the cylinders tight. I brought the subject up, thinking that probably other members had had the same trouble, and I might learn something from their experience.

Mr. DAVID BROWN—Do I understand the gentleman to speak of cylinders breaking on the saddle from the frame up?

Mr. GENTRY—Yes; right square through the saddle.

Mr. BROWN—We have had 19 x 24-inch passenger cylinders breaking in that way and we have put a brace back and front of the cylinders and run them quite a long time. But we attribute it more to the thinness of the walls. When we put new cylinders on we made the walls thicker, and we did not seem to have any further trouble. With engines that have the boilers on top of the frames, there is a tendency to swing probably a little more, and they have given us trouble, but by bracing them with a cross-brace back and front, tying them together as it were, we seem to have overcome the trouble.

Mr. MITCHELL—We have a large number of that type of engines, and we had the same trouble with them, but we overcame it to a great extent by increasing the walls of the cylinders, and at the same time putting a T-brace between the upper and lower member of each frame, just back of the cylinders, so as to protect those bolts from working through the cylinders, and putting braces laterally across the frame. In some instances, we have put a yoke right around the upper and lower member of each frame, both fore and aft of the cylinder.

Mr. JAMES MCNAUGHTON—I might say that we have had a few cylinders break as described by Mr. Gentry, and we have overcome the difficulty, as the other gentleman describes, by bracing the cylinders back and forward, and in some cases taking the flange off the saddle both forward and back, and tying both the cylinders together with a planed plate. But the fault is

due to faulty design of the engine, and in making the new patterns we have thickened the walls and hope to overcome the trouble. We have had some experience with cylinders getting loose on some mogul engines, particularly in the saddles. We have done nothing about that except to reinforce the smokebox with heavier plates and bolts, and I find that the pedestal braces in connection with frame troubles is something that must have careful attention. There are some pedestal braces to which I think the trouble of broken frames might be attributed. But my experience is that they must be kept tight, and some of my trouble has been traceable to that fact, faulty pedestal braces.

Mr. GENTRY—I would like to ask the gentleman if he uses what is known as the thimble brace or does he use a bottom brace that is planed out and fixed in the bottom of the pedestal?

Mr. McNAUGHTON—I use both.

Mr. GENTRY—From which, in your opinion, have you obtained the best results?

Mr. McNAUGHTON—I might say we use three. We get the best results from the old strap.

Mr. R. D. WADE—We commenced using consolidation engines some seven or eight years ago, and our trouble from broken cylinders and frames did not occur for the first three or four years. But the speed of the trains was a great deal less then. In the last two or three years we have got to running fast freights and vestibule trains with a schedule that sometimes requires a speed of forty miles an hour. I refer now to the consolidation engine with small wheels. That is not the right type of engine for fast speed. The compression and the impossibility of counterbalancing for high speeds causes great strains on the cylinders and on the frames, and that, in my opinion, is what causes the breakage. I know that has been my experience.

Mr. S. L. BEAN—We have had some failures of loose bolts, and in one case we broke the flange of the cylinder clear around. I merely braced up by ¾ rods all around, which has held very well. In all cases we renewed the bolts. It was my opinion that the first fits of bolts through the saddle and frame were defective—loose. That caused the trouble. The keys worked out. By riveting and re-reaming and taking exceptional pains we have had no trouble whatever with loose cylinders.

Mr. J. M. BOON—The starting-point is bad workmanship. Almost invariably when a cylinder works loose on the frame it will be found on examination that the bolts originally put in were not a good fit—were too loose. At the very moment there is the smallest particle of play there it makes a starting-point for breakage. Another cause of frames breaking is that too large-sized bolts are put into the frames. I know of locomotives that have got frames 4 inches wide and they have got 1¼-inch bolts through those frames to hold the cylinders. They cut away more than 25 per cent. of the strength of the frame with that bolt. The result is the frame breaks through the hole. It could not be otherwise.

The same line of weakness exists to account for cylinders working loose. We are now increasing the diameters of the cylinders. We are throwing up the center of the boilers above the cylinders. The leverage due to the distance between the center of the boiler and the center of the cylinder, in comparison with the old practice, is enormous, and in working full steam on these cylinders carrying from 150 to 180 pounds pressure, the strain there is terrible, and yet we find locomotives that are going out, designed for that kind of practice, with a cylinder plate too small, too light. The result is the moment the engine gets working, something must go. If it is the frame that is the weaker point, it is going to break there. If it is the cylinder, it is going to let go there.

Another thing—a great many cylinders are cast that are not properly designed. We all know that in making a casting like a cylinder, the difference in the shape, the change of circle and changes of direction, the disposition of metal—all have to be taken into consideration. Yet you will find large masses placed in one point while another point is light. When the cylinder is cast the trouble commences. It is cast on a strain—unequal expansion, and the cylinder gets hot and cold alternately ; and the time comes, and very rapidly, when something is going to let go. The only way to stop frames from breaking and to get cylinders to last is to make them right at the start, and you will then have no trouble.

Discussion on Broken Piston-Rods.

Mr. Gentry—Before we leave this subject, I want to mention a matter that might be interesting to most of our members. We have had fifteen cases of broken piston-rods in less than as many months, right straight along ; that is, just on my division. Going over the matter right carefully, I have noted that eleven of those fifteen rods broke on the left side and only four on the right. A large majority of them broke between the shoulder and the key slot ; some right at the shoulder, some in the key slot, but the majority did not break in the key slot. Out of twenty-three cases of cracked and broken cylinders, eighteen of them are on the left side. Our engines lead right handed. I would like to know if anybody can advance any theory or reason for that.

Mr. Wm. McIntosh—We have had some loose cylinders on our line, but we attribute the difficulty to bolts improperly put in—poor workmanship. We find when they are re-keyed—new bolts put in, the trouble ceases.

Mr. Setchel—I would like to ask Mr. Gentry what kind of guides were used where those piston-rods broke ?

Mr. Gentry—In the majority of cases the Laird.

Mr. Brown—The way to keep piston-rods from breaking is to examine them occasionally. We have had rods broken. We adopted a system of taking them out occasionally, looking at them. We have very few broken rods. We get caught once in a while. We got caught quite recently on an

engine. The rods of that engine had been examined some six months previously, and she was about ready for the shop, but something else came in which we thought was worse, and we let her run for probably three weeks after the time we intended to take her in. The consequence was she came in with a piston-rod broken in the keyway, knocking the front end of the cylinder off and causing a patch. If we had brought her in at the time intended, we would have seen it, because we make a very close examination of the piston-rods, especially around the shoulders and keyways, as well as at the head. But I find that if we run an engine over ten months or a year, with the service that they get on our road, that there is certainly a flaw around the hole or in the shoulder.

Mr. GENTRY—We do not attribute our trouble to a lack of close inspection, where it is possible to give it. Our engines do not lie over quite long enough to give us the opportunity of inspecting the key-rod and all that. I do not see how we can depend on any inspection of them. We had a case where a new rod was put in on one side, and we had an idea that while we were doing that we would slip the other one off. Fortunately we did, and we found a crack in it. We would not have done that under any other circumstances, probably. Ordinarily we cannot do it.

Mr. MACKENZIE—Mr. Gentry makes the remark that the preponderance of these breakages is on the left hand side of the engine. I would like to ask Mr. Gentry if he can give any cause for that—whether it is because the engineer pays more attention to the right hand side than he does to the left, or whether the fireman has neglected his business? He might be deaf on that side.

Mr. GENTRY—I would state for Mr. Mackenzie's benefit that that is just why I raised the question. I stated that our engines all lead on the right side. I thought probably that would give some member a point to start his fishing from. I know it to be a fact that on the Pennsylvania Railroad a large majority, if not all, of their engines lead left handed. If there is anybody here who can give us any information we should be glad to get it. Probably they may have most of their trouble on the right side.

Mr. WILLIAM SWANSTON—We have both rights and lefts. I think they are about equally divided on our divisions. I cannot tell that there is much difference. We have broken cylinders on both sides. I have probably about ten passenger engines running now with broken cylinders in the saddle, and I cannot tell the difference.

Mr. BEAN—I would like to ask what class of service the engines referred to by Mr. Gentry were in mostly, passenger or freight?

Mr. GENTRY—They are mostly in freight service, heavy freight service.

Mr. WILLIAM SMITH—We make a practice of examining our piston-rods about every two months, and with all that we occasionally slip up on some of them. But we catch a good many, and we have had more difficulty with steel rods than with wrought iron rods. We have partly abandoned the steel rod now and gone to wrought iron.

Mr. JAMES MCNAUGHTON—I believe that I can hold the record on

broken piston-rods, particularly in the Laird crosshead. I would like to ask the gentlemen if in their examination they heat the rod in any way in order to bring out the defect. Without that, I do not think it can always be discovered. As for iron and steel, I have tried both and I get the best results from steel.

Mr. SETCHEL—I would like to ask Mr. Gentry if he attributes the breaking of his rods in any degree to the Laird guide. That is a very popular guide. I think that probably 75 per cent. of all the engines manufactured now are manufactured with the Laird guide.

Mr. GENTRY—We are looking around for reasons and for information. Really, we have not attributed it to anything in particular, except that we note what Mr. Brown said a while ago, that these cylinders were made at the manufacturers and were put in the engines when built. The cylinders we are putting in are not breaking. We have had some running now about fourteen months, and we have not had a broken one of our own make. But we have a better disposition of the metal, a better pattern and thicker walls, and I think we have done a better job of reaming and bolting. This trouble is mostly in cylinders that are put on when the engine is built.

Mr. POMEROY—In putting some questions to Mr. Smart, of the Michigan Central, he said that when the crossheads were only 18 inches long in the Laird guide, he had a great deal of breakage, but since he had re-designed his crossheads and made them 20 inches, he had not broken a single rod. Since there was plenty of bearing there has been no trouble.

Mr. SMITH—We have quite a large number of Laird guides on at present. We have them about 22 inches in length. We find about as many broken piston-rods in the eight-bar guide as in the Laird crosshead We have never had any trouble with the crosshead particularly, and I think there is no more trouble with that crosshead, with a good long bearing, than with the four-bar guide—that is, if the crosshead is not permitted to run with much lost motion. If vertical movement is permitted between guides and crosshead, the Laird causes broken piston-rods.

Mr. VAUCLAIN—I wish to refer to the statement made by Mr. Setchel that he believed that 75 per cent. of all the engines built were manufactured with the Laird guide. I wish to say that over 75 per cent. of all the engines we build are built without the Laird guide. I think Mr. Smith's reason for broken piston-rods is about the true one—that is, crossheads are allowed to go with considerable lost motion, and it is more liable to happen with the Laird guide than with any other guide in use.

Mr POTTER—I would like to ask Mr. Gentry if he did not find in nearly every case where a piston-rod broke that there were indications of the rod having been loose in the crosshead.

Mr. GENTRY—No, sir; not by any means. On the other hand, we had to force the ends out by pressure.

Mr. POTTER—I mean evidence of being loose at the larger end.

Mr. GENTRY—No; not in all cases. We very often find an indication of a loose rod, you know; we could slip it out and see that. Our experience

is that where the rods are well fitted and driven home tightly to the shoulder they just break right off. In nearly every case there was evidence of a fracture having existed for quite a little while. I do not know that we had any that showed that they broke right off at once—a complete fracture; but in nearly every case they are good fits.

Mr. POTTER—I would like to ask, are your piston rods so made that they draw against the shoulder?

Mr. GENTRY—Our rods are so made that they draw against the shoulder, and we do not use the key for drawing them either. Our keys go one from the bottom and one from the top. We drive the piston-rod home with a big butt and key it up with these temporary keys, and then we drive the key in as it is going to remain.

Mr. POTTER—Our experience has been, in nearly every case where the piston-rod has broken, that it has shown indications of having been loose at the larger end, and the reason that we have thought was the possible reason for that, was that the shaking of the piston-rod had frequently caused it to become looser in the crosshead. The key will hold the small end rigidly, and if it becomes loose at the larger end there is a vibration, and if that goes on it is liable to cause it to break. It has been suggested that this difficulty might be overcome by making a taper to the crosshead fit and doing away with the shoulder altogether, so that if that end of the rod did become somewhat loosened inside, by removing it and replacing it, it could be drawn in and the fit maintained throughout the length of that portion. I would like to hear from some of the gentlemen who have tried that arrangement.

Mr. SMITH—If the piston-rod was a good fit in the crosshead when it was put in and became loose afterward, it would suggest to me that the guides had been allowed to run very badly or were otherwise loose, and that was the natural cause of getting loose in the crosshead.

Mr. MACKENZIE—Mr. McNaughton, I think, said that he wanted to take the record on broken piston-rods. I want to challenge him on that. I think we have had more piston-rods broken in proportion to the number of engines than any other railroad in America. I attribute the whole cause to defects in mechanical construction, the piston in the crosshead being too small in every case. The practice is that they apply this 3¼ piston-rod and then reduce the piston fit in the crosshead to about 2¾ inches at the largest diameter. The consequence is that when they get an $\frac{11}{16}$ key into it there is not any rod left. Now, our practice, and we find it to work very well, is to increase the size of the diameter of both the piston fit and the crosshead fit, and make it just barely a small diameter below the size of the rod itself. We find that with this packing we use now it is not necessary to turn piston-rods, and when we run them so long that formerly we would have to turn them, we now throw them away. Now, by increasing the fit ½ inch nearly throughout, we have done away with broken piston-rods, in a manner.

I am a good deal like Mr. Vauclain about the Laird guide. There is

where the whole source of our trouble was. We have had some engines built with the double-bar guide, and we have had no trouble with broken piston-rods.

Mr. E. M. Roberts—We have had considerable experience with broken piston-rods during the last year, and we attributed it first to the corners in the keyway. We remedied that by eliminating the round corners, and we found that our piston-rods would break in the center of the keyway. We increased the sizes where we could. We have quite a number of freight engines with Laird guides, and we never had one break; but the breakages have always been with passenger engines with the four-bar guide. They are steel piston-rods, and we attribute it to several reasons that have been mentioned here—first, rather too short bearings for your crossheads and with a disposition to allow your crossheads to run, particularly where you are short of engines, with considerable more wear than would be proper and right perhaps, and with a bad fit, or depending upon machine fit of the rod in the crosshead. Of course, it looks like going back a step, but I believe a good many of these troubles could be eliminated by going back to the old practice of grinding our piston-rods into our crossheads. It has got to be such a serious matter that we have now taken up the question of putting in iron piston-rods to see if the result will be the same.

Mr. Smith—I would like to say that in our Laird guide our piston-rod is 3¼, when the rod butts up against the end, and we have a long dividing fillet, and probably that may be one of the reasons why we have so little trouble with the Laird guide.

The President—Gentlemen, the noon hour having now expired, we will have to defer further discussion of this topical subject. Let me say that this subject will be continued at noon to-morrow, and I would like to say in connection with that, that the noon hour discussion of questions presented has been one of the most profitable that our association has had for years past, and I would suggest that members who have any of these subjects send them to the secretary in order that they may be discussed at the noon hour of each day.

The meeting then adjourned till afternoon.

AFTERNOON SESSION.

The Convention was called to order at 2:45 P. M.

The President—Gentlemen, the next business is the report of the Committee on Tests of Iron and Steel. The chairman of that Committee is Mr. William Smith.

Secretary Sinclair—I may explain that the next report in order is

Compound Locomotives. I received it only on Saturday morning, and it is in the hands of the printer. I am expecting to get sufficient copies this afternoon to go on with the report.

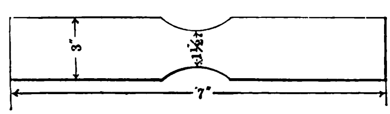
Mr. D. L. BARNES read the following report from the Committee on Tests of Iron and Steel:

TESTS OF IRON AND STEEL.

Your Committee appointed to report upon the subject of iron and steel for locomotive boilers and fireboxes, beg leave to submit the following:

A series of observations have been made on firebox steel that has been in service as long as eighteen years down to steel that has failed by cracking in less than six months' service. It is almost impossible to reproduce the various phenomena observed in the fracture of these pieces so as to embody the same in this report. No adequate idea can be presented except by an actual inspection of the broken pieces.

The sample pieces were cut out to a size of 7 x 3 inches, and punched on the sides, so that the fractured surface was 1½ inches long, thus:



These pieces were then broken by bending alternately forward and backward, to an angle of about thirty-three degrees from the plane of the piece. In a number of cases the sample was nicked slightly, and the nicked samples seemed to produce a fracture that would give a better idea of the characteristics of the steel than those which were not nicked. The more frequent bending of the samples not nicked so affected the appearance of the fracture that little could be determined therefrom. The same trouble is experienced in observing the fracture of a piece subjected to a tensile test on the machine. In such pieces no idea can be formed of the character of the crystallization, and but a slight idea of the tendency to lamination. In the bending test, if the samples are nicked, a very clear idea of the crystallization is attained, and frequently, of the amount of lamination. When the samples were not nicked, the character of the crystallization was much

affected in breaking, but the presence of lamination was made very apparent. It is, therefore, the opinion of your Committee, that in addition to the usual tensile test, the samples of steel should be subjected to a bending test until fracture occurs, and that this test should be made on both nicked and unnicked pieces.

In nearly every piece subjected to the bending test, more or less lamination was observed. Some of these laminations were less than an eighth of an inch in width, and looked as if they were caused by minute bubbles of gas, and they varied in size from this to a size extending almost across the fracture. These laminations were decidedly less apparent in the steel which had been long in service, although a slight lamination was observed in the piece longest in service. Your Committee are inclined to believe that an idea of the durability of steel can be formed from the amount of lamination observed, and that the most durable steel will be freest from the same, but it is not yet quite prepared to take a decided stand on this point They would recommend, however, that this method of test be added to the usual tensile test by the members of this Association, and that results be carefully watched to verify or controvert the position taken.

Undoubtedly steel-makers, by observation on this point, could throw considerable light on the subject. The following questions naturally arise: Is the presence or absence of lamination due to manipulation on the part of the steel-maker, or to the character of the raw material used? Can lamination be avoided by manipulation of the molten metal? Can it be avoided by discarding a larger portion of the top of the ingot? Is not the tendency to cheapen production largely responsible for the apparent increase in lamination in steels of later manufacture?

Steel-makers could undoubtedly throw considerable light on this subject if they are willing to do so, but your Committee feel utterly at a loss to give answers that would be of any value. At the same time they are fully convinced that the present specifications requiring a certain chemical composition of the steel, and a certain tensile strength and elongation, are not sufficient to insure satisfactory results, so far as durability of steel for firebox purposes is concerned.

In addition to the phenomena of lamination, there is a very

great difference in the color and character of the crystallization displayed in the surfaces of fractures of the different samples, as well as sharpness of the same to the touch. The character of crystallization can undoubtedly be very much modified by the manner of cooling, and therefore in making observations on crystallization it would seem that the pieces should be subjected to uniform treatment as to heating and cooling before being broken. It is the opinion of your Committee that deductions as to the quality of steels can be made with great accuracy from the general character of the crystallization, but that to do so a large amount of prior observation and experience will be required. It is well known that all large business houses buy simply on expert inspection without attempting anything in the way of specifications. Railroads, on the contrary, buy all their steel on chemical and physical specifications, and, as far as your Committee know, entirely ignore the question of expert inspection. In fact, it would be difficult to find to-day on any railroad an expert employed as such who would undertake to grade a lot of twenty samples of steel, running from good tool steel to the cheapest products, in accordance with their prices and qualities ; while at the same time there is good reason for believing that with proper training such grading could be very accurately done. This method of grading is practiced in almost every line of trade. Step into a jeweler's establishment, and he will show you two diamonds of the same size and nearly the same appearance, but one is worth twice as much as the other. The dry goods man shows you silks varying in price from $1 to $10 per yard. The millions of bushels of wheat which change hands yearly are valued by expert inspection. The same is the case with almost every item of trade. In steel for boilers, this kind of inspection seems to be entirely ignored.

Your Committee are decidedly of the opinion that certain requirements as to chemical composition, tensile strength and elongation, do not insure the best quality of steel for firebox work. It is not certain that further inspection as to character of crystallization, etc., will do so, but there are good reasons for believing that such inspection would be of material benefit if made by an expert. The assertion has been made that no experts employed as such are to be found to-day. It should not be under-

stood from this that it is thought that no such experts exist. On the contrary, it is believed that in nearly every shop there are a greater or less number of men who are quite capable of passing an adequate opinion on the relative merits of various sheets of steel from inspection of the fracture, who can say that one sheet is more liable to crack than another when used in a firebox of a boiler, in that one sheet will flange better than another. If, now, a man with such experience, a man who has worked steel and observed in his daily work on boilers how steel fails by corrosion and cracking, were to further extend his experience by systematically inspecting fractures made of all sheets that are used and are taken out of service, including good, bad and indifferent, he could not fail in the course of time in so educating his eye and judgment that his opinion would be almost infallible. If such a man had a preliminary experience in a steel-producing plant so as to familiarize himself with the processes of manufacture and materials used, it would undoubtedly do much to improve his efficiency. It is not to be supposed that any man will educate himself to make such an expert, and would be able to do so. The vast majority of men perform their daily work with their eyes shut to everything except just what is required to complete their daily task, but out of the sum total a few are always to be found who possess the necessary qualifications.

It is believed that in no way can a more decided advance in satisfactory boiler-work be made than by proper learning and use of such an expert.

It is not intended that this system of inspection should dispense with present chemical and physical specifications; these have been made, or at least should have been made, from analyses and tests of steel that have given good results in actual service, but necessarily ignore much that is due to manipulation, and it is the importance of the points ignored on which your Committee dwell.

It would be quite possible to get up very neat specifications, chemical and physical, of a loaf of bread; the crust must be so thick and of such a color, it must weigh so much per square inch, the pores must be of such a size and uniformly distributed; it must contain so much water, salt, gluten, starch, silica, phosphorus, etc., or if we analyzed to its ultimate composition, so

much carbon, hydrogen, phosphorus, etc. This would all be strictly in accordance with the composition and qualities of a good piece of bread, but if an expert with fair experience in gustatory requirements, and we have many such, were employed, he would tell us more, and decide more definitely as to the qualities of that piece of bread, when he got a piece in his mouth, than by the most elaborate investigation on the line of the specifications outlined above. His decision also would be based on qualities which could not by any means be formulated in specifications.

Comparisons are dangerous, and the above is not intended as being a case parallel to the one under discussion; at the same time, it approaches very closely, in many respects, to being a true parallel; and if your Committee succeed by this report in furthering a full and careful investigation of the merits of the expert system as outlined above, they will feel that they have done no small thing in advancing the art of manipulation of steel.

WM. SMITH,
J. N. BARR,
A. W. QUACKENBUSH,
P. H. PECK,
D. L. BARNES,
Committee.

DISCUSSION ON REPORT ON TESTS OF IRON AND STEEL.

Mr. D. L. BARNES—This report on Tests of Iron and Steel is signed by all the members of the Committee, except myself. This is the first time I have seen it. I do not agree with it, and I would prefer to make a minority report, with the permission of the Association.

Mr. SETCHEL—I move that the report be received.

The PRESIDENT—It is moved that the report be received and placed on file.

The motion was carried.

Mr. SWANSTON—Does that shut out Mr. Barnes from making a minority report?

The PRESIDENT—No, sir; it does not. A member of any committee is entirely at liberty to submit any report he sees fit. I see Mr. Barnes' name is attached to this report. If Mr. Barnes wishes to present a minority report to the convention he can do so.

Mr. D. L. BARNES—As a minority report, I would submit that I am decidedly in favor of specifications of steel, and it is my belief that when the steel shows a proper chemical analysis and has a proper physical test, and is

made according to well-known processes for making steel, that it would be a good material for a firebox. As to chemical analysis, we know a good deal about it. Physical tests, including bending tests, are well known and so well described in all sorts of technical literature that it is not worth repeating a description of them. But to make good steel in a steel-producing plant is quite a difficult matter. It is true that a railroad expert ought to know a lot about the manufacture of steel, and if he does not know it is very easy to find it out. If the bottom of a bloom that has been properly or reasonably well cast is cut off and then hammered well and cross-rolled the width of the sheet, and then lengthwise rolled to the length of the sheet or down to a proper thickness, that will be a good sheet of steel, perfectly safe for fireboxes, provided the other chemical and physical tests are made, and that is the plan which is followed in this country for Government work of the very highest grade and for all steel made in Europe.

I think that that statement is more in keeping with the present condition of steel manufacture than this report.

The PRESIDENT—As I take it, this is merely a criticism of the report. Mr. Barnes simply criticizes the report of the Committee. I am desirous of knowing if Mr. Barnes intends to submit a written report. Do you, Mr. Barnes?

Mr. BARNES—No, sir; I would like to make that as a minority report.

Mr. L. R. POMEROY—On reading this report, I did not understand that the Committee had any objection to the standard tests, but only suggested others in addition to them. You notice they go on and magnify the chemical test, the tensile test, the nicking test, and then they speak of others in addition. I do not see that the criticism of Mr. Barnes is any improvement upon the recommendations submitted by the Committee.

Mr. S. M. VAUCLAIN—I think when you get away from the scientific inspection of boiler plate that you are losing ground. It has taken us several years to arrive at the proper specifications for boiler plate, and if they are not perfect now, they are a great deal more perfect than what they were several years ago. I think it is not right to compare the inspection of boiler plate to the eating of a piece of bread. You might chew boiler plate until you wore your teeth out and not know any more when you got through than when you started.

We handle about 150 tons of boiler plate weekly. We have specifications that we have arrived at after years of practice and with reports coming in from material that we have sent out. We have also had specifications of all our customers compared one with the other and decided upon which one is the best. We have taken out a number of good sheets from each one of the specifications submitted and we try to keep ours in as good shape as it is possible to keep them. I find in handling boiler plate that the principal difficulty to overcome is that of lamination, and the one thing to know is how to detect it. I am frank to say that I cannot detect it until we first put it in the fire. The only way in which we can detect laminations in plate, unless they are very gross and one can see them at a glance—and in

that case no manufacturer of steel plate would ship the plate to you—we cannot discover them until the sheet is flanged, and in some cases until after the sheet flanged has been removed. I think that, as Mr. Barnes has said, the proper way to get good steel is to make our specification right and live to it. First arrive at a proper specification, and then see that it is lived up to.

Mr. WM. SMITH—I want to say to you that there are no specifications that you can get out that steel makers cannot get around. Out of twenty-five samples that were broken up and gone through, you would scarcely find two of them alike, and some of the steel was of poor quality; it looked like shelled rock more than anything else. The color was dark and dirty, showing that the stuff had not been cooked, and whether the stock that entered, that was of a proper quality or not I cannot say, or whether it was spoiled in the cooking. It is one or the other. One steel maker from Pittsburgh happened to be around at the time when this lot was broken up. I asked him if he could grade the quality of the steel. He graded the quality of the steel as it stood in the fireboxes, with only one failure Mr. Barr, of Milwaukee, was also asked to grade the steel, and he made only one or two mistakes. The steel has stood its service, and I know its whole history. With two different lots of steel made by the same party, but about four years apart, there was a marked difference in the falling away of the quality. I am under the impression that I can tell more through a tensile test —and then a fracture afterwards—about steel than in any other way. I think if the members of this association would take the pains to break up a lot of fireboxes indiscriminately that have given good, bad and indifferent service, they would agree with what I say. I think if you go to the scrap pile you will tell more about steel than in the laboratory. (Applause)

Mr. WM. SWANSTON—I would like to ask Mr. Barnes or someone else if it is not a fact that while we grant that the physical and chemical tests are essential and good, that we get steel that meets all those specifications and yet does not do the work in the firebox? I have seen a good many instances of that kind. On one of the divisions under my charge, I cannot keep a firebox over an average of two years, and I think a good many times that it is the steel. We have had steel that met the specifications and failed entirely inside of nine months. I am not prepared to say just what the cause is. I would like to know if it is not a fact that we can get those chemical and physical specifications and yet not have the steel we want.

Mr. BARNES—I think it all depends upon the specifications. There are many specifications, as there are many men preparing them, and if the gentleman will present his specification——

Mr. SWANSTON—The specifications I refer to are the P.R.R. specifications.

Mr. BARNES—The P. R. R. are perhaps unfortunate. I believe they have changed their specifications.

Mr. JOHN MACKENZIE—I would like to ask Mr. Swanston if he finds this failure under the specifications from different manufacturers of steel, whether the failure is more with one than with another?

Mr. SWANSTON—I would answer that I believe it is about equally divided. Recently, I think, it is about the same in all of them. Some years ago I asked for Otis steel because I had had very favorable results from it. I had had a number of fireboxes of Otis steel that were in service for about ten years. I asked for Otis steel, and I got about ten or twelve fireboxes, and they were no better than the rest.

Mr. BARNES—I think I ought to explain myself a little more by stating an actual case to show the confidence of steel makers. I have recently had forty-five engines built for a road, under specifications, and after making the most rigid specification that I could make, to conform to the best practice of the United States Government, I asked the steel makers to guarantee the fireboxes against lamination for five years. Several bidders on those specifications accepted that condition. They did not make the steel, perhaps, in the way that they ordinarily would; but they can make good steel if they agree to do so.

Mr. SMITH—The trouble with our road is not so much lamination as it is the cracking of the sheets. Some of them crack inside of six months. I have two or three samples of the steel I picked up at random a week ago. If any of those members who put so much dependence on specifications would like I will show it to them and ask what they think of them, and to pick out what they consider the best steel.

Mr. WILLIAM FORSYTH—I must say that I am very much surprised at the tone of this report. It states distinctly here that "your Committee are decidedly of opinion that certain requirements as to chemical composition and tensile strength do not insure the best qualities of steel for firebox work." The Committee go on to explain in what they think is the best way to insure that, and so far as I can get their idea, it is that you are to train up an expert by the examination of scrap piles and crystalline fractures until you have got a man who can tell by the sight of those fractures whether the steel is good or not. Now, I submit whether this is a practical thing to offer to consumers of steel plates as a substitute for chemical analysis and tensile tests. We have been buying steel to physical test for about fifteen years, and we have comparatively few cracked plates. I think this trouble with cracked plate is a local one, and it seems to have broken out in rather a virulent shape on the Northwestern road, and I should say that it is certainly due more to the construction of the boilers or the manipulation of the sheets, or the treatment of the firebox, than to the quality of the steel.

Mr. PULASKI LEEDS—About eleven years ago I had instructions from Mr. Wells to build sixteen engines. He bought four engines of three different kinds of steel. There were two kinds of that steel which the foreman of the boiler shop called my attention to when working in the shop. He said: "It is the best I ever saw." I immediately had pieces taken from that and chemical analysis made, and I also had physical tests made, as I did also of another very high grade steel. The engines were built and put into service under almost exactly the same conditions. In fact, there

was part of the time that they were interchanged from one division to another. After running for eight years there were eight of those engines that had not shown a blister or a crack, and apparently were as perfect as on the day they were put in. Of the other four, every one had a crack on each side of the firebox within half an inch of 32 inches from the mud-ring up. Every measurement was within half an inch of the 32 inches.

I then drew up specifications after eight years' service and experience with those eight engines—that was an average of the four of each manufacturer—and sent it out to the steel makers. I very soon had an interview with an expert from one of our largest steel manufacturers, and he said that I was altogether too rigid. I told him that I did not think so; that it had been proved to me very satisfactorily that those specifications would give a perfect steel. I also showed him the other steel that cracked. That showed a very fine crystalline fracture, which indicated that it was a perfectly homogeneous steel as far as could be judged, but rather high in carbon. He then showed me his tests of a great amount of steel that he had been manufacturing, from the Government and from stationary boiler builders throughout the country, and I found that in scarcely any instance did he exceed any of the points that were in this first-class steel. I also had pieces cut from those fireboxes that were perfect and had them analyzed, and, contrary to all assertions made by steel manufacturers, we found that the sulphur had increased materially in the whole of them, and that the steel was harder than the samples taken from the new steel when put in the boilers; that it showed a shorter, more crystalline fracture, and to a great extent was c anged a good deal.

The other four engines were made of another quality of steel. In breaking the specimen from the new fireboxes that were built, they showed a slightly fibrous structure—in fact, they looked more like iron. But at the same time it appeared as though there had been slight bubbles there with a cinder between them. very much like iron. Those fireboxes blistered a great deal, but none of them ever fractured.

I have about made up my mind that inasmuch as that steel that showed this fibrous fracture showed almost exactly the same chemical analysis, almost exactly the same physical tests as the steel in these fireboxes that have run now for nearly twelve years I have made up my mind that there is a great deal in the raw material; and while I should most assuredly insist that our manufacturers should apply every known test of chemistry and every physical test, at the same time if we could buy our steel, as we buy our wheels, under a guarantee, and put the responsibility on the manufacturer and let him depend on his chemistry, I think that it would be a great deal better than for us to lay down cast-iron rules to him—that he shall make a steel that shall fill certain requirements and at the same time last from twelve to fifteen or eighteen years. (Applause.)

Mr. Barnes—I know of one or two locomotive builders who are building locomotive boilers and giving a guarantee for their performance, provided they are allowed to put in such material as they think best and al-

lowed to make their own boiler design, and provided also that the railroad company will agree to wash them out with hot water, without firebrick arches in them.

Mr. LEEDS—I would say, gentlemen, that when I insisted on our specifications being lived up to strictly, they said we will have to raise the price of your steel from a quarter to half a cent a pound, inasmuch as we have to get a different ore to make it from ; and I am pretty well convinced that there is a great deal of difference in the raw material.

Mr. CHARLES BLACKWELL—So far as the Schoenberger firm which I have the honor of representing is concerned, they try to make the best steel they know how. If it fails, they want to know it. If they find it does not fail and works well, they want to know it. At the same time, I know that they consider that the steel that they look upon as their best brand of steel is the best that they know how to make. What they consider the most dangerous steel for firebox purposes is steel that is high in phosphorus and high in sulphur. Those are the two most dangerous elements. They consider that for firebox purposes these elements should be kept as low as possible. They also consider that lamination is a very serious detriment to firebox steel, and I think that their steel, as compared with other steel, is about as free, or more free, from this defect than any other. They consider that a strictly homogeneous steel is the perfect steel for fireboxes ; that is, steel showing nothing in the shape of fibrous structure when broken—a strictly crystalline structure. Of course, any steel-maker is apt occasionally to have a bad sheet go out. So long as the operations in the mill are taken care of by men, these men occasionally make mistakes. Sometimes they will overheat an ingot, and the part of the sheet which is rolled from that overheated part is bound to be unsatisfactory ; whereas, perhaps the part of the sheet rolled from the unburnt part of the ingot is all right. Now, in taking a test piece of that large sheet for the satisfaction of the manufacturer, to see what the sheet is like, that test piece may have been cut off the edge of the sheet which was rolled from the good part of the ingot and it may show good results. If that sheet is cut up into half a dozen smaller ones, they may perhaps have failure from one or more sheets that were rolled from the burnt part of the ingot. So that it is really difficult for the steel manufacturer to say that every sheet that goes out of his mill is absolutely first-class in every respect. But so far as my experience has gone it is that lamination is a very serious defect in firebox material.

Mr. BARNES—I would like to ask one more question. Mr. Blackwell has admitted that there is a lack of uniformity in the manufacture of steel. Therefore, in his yard he must have steels that are good and steels that are bad, and I would like to ask him how we would go into his yard and take out a first-class piece of firebox steel? How can you make the examination to tell us?

Mr. BLACKWELL—I should make a chemical and physical examination of that sheet. I should examine for the different elements—carbon, phosphorus, silicon, manganese, and so on, and I should pull it, see the tensile

strength, see the elongation per cent., and I should nick it and see if I could discover any lamination in it. The great trouble about the nicking test is that you may have a test piece that shows no sign whatever of lamination, and right alongside that test piece may be a lamination extending over perhaps 12 or 24 or 30 inches in area. You are not sure about it at all. The nicking test is a very good test so far as it shows the absence of lamination in the test piece itself. You may have bad lamination in the test piece and hardly any in the sheet, and *vice versa*.

But in answering that question I should say that the piece of steel that would give the best result would be the steel that was lowest in the impurities, that had its strength entirely, or as nearly as possible, by carbon and not by phosphorus or sulphur or other impurities, and one in which the tensile strength was within reasonable limits, according to the water used or the territory in which the box is going to be used, and freedom from lamination. If I had those results I should consider, other things being equal, that that sheet ought to give better results than a sheet in which the impurities were higher and in which lamination was present.

Mr. SMITH—I would like to ask Mr. Blackwell if chemical analysis will show whether the stock is good—whether the material is made from good stock or whether it is made from an inferior quality of stock?

MR. BLACKWELL—Answering that, I am very sorry to say I am not a chemist and cannot give a reply to which I would like to swear. But I should say that on general principles it would not. You might have iron made from ores obtained from all parts of the country and giving exactly the same chemical analysis. You could not tell the stock it was made from. That is my personal opinion.

Mr. W. H. MARSHALL—I notice in the second paragraph of this report that the first sentence states that a series of observations have been made on firebox steel that has been in service as long as eighteen years, down to steel that has failed by cracking in less than six months' service. I should like to ask the Committee if those observations have included chemical tests and physical tests, and also, if this be the case, whether there is not some information in them that would be of value to the association and from which some conclusion could at least be drawn?

The PRESIDENT—Will the Committee answer the question of Mr. Marshall, please.

Mr. SMITH—While some of the fireboxes referred to were put in by builders, others were put in at the West Chicago shops. The engines built for us have been built to our specifications, and, so far as I know, the iron must have been up to the specifications of the Northwestern road, and I know some of it that came up to the specification, and some that I know had been tested failed inside of ten months. That is physical specifications.

Mr. MARSHALL—No chemical tests?

Mr. SMITH—No.

Mr. G. R. HENDERSON—A great deal has been said about the inspection of test pieces taken out of the firebox. I do not think there is any doubt at

all but that the examination of pieces after they are taken out will give a very good idea of the kind of steel. But I also believe that those tests, if taken before the sheet was put in the box, would give a very different fracture, and I doubt if you could judge of the fracture of the steel before and by the fracture you would get after a firebox had been in service four or five years.

Mr. Leeds—I only want to ask if these remarks are taken from what I said, that the analysis was make from steel taken from the firebox after being put in service? I would say the analysis was taken from the new steel before it was put in the fireboxes, and again after eight years' service, and, with the exception of sulphur and a slight variation in phosphorus, there was no variation of the analysis after eight years' service.

The President—Gentlemen, as you are aware, we have Mr. Jackman here, who represents a steel manufacturing house, and perhaps he could give the association some valuable points if they would permit him to speak. He is not a member of the association, and can only be permitted to speak by unanimous consent of this meeting. If you desire to hear from Mr. Jackman you can make a motion to that effect.

Mr. Swanston—I move that he be allowed to address the meeting.

Mr. Gentry—I second the motion.

The motion was carried.

Mr. Jackman—I am afraid there may be some misunderstanding. I am not a mechanic, nor a manufacturer. I was accompanied here by Park Brothers & Co.'s manager and also a member of the firm, who are well prepared to talk from the technical standpoint, but I thought that one who was a salesman might clear the way for a discussion later on by more practical speakers. Now this question has not been brought up by steel manufacturers. They can make just as much money on cheap steel as they can on the higher grades. This question has been brought up by the master mechanics through the country, and the question is whether the steel they are now putting into boilers and fireboxes, on the system of inspection and special requirements, is giving the railroads as good service as the steel they bought years ago that was not subject to these tests? As a salesman, of course, I am expected to protect the reputation of the manufacturer and to win the approval of the purchasing agent, and then if the material is not satisfactory in use, the salesman has to try to escape the wrath of the mechanical department, so that a salesman meets this question on three sides. Now, I do not think it is the intention of Mr. Smith or Mr. Barr or any of the steel makers to wage a war on the requirements and tests of railroad companies. Those things are all right. They represent a great deal of skill and study on the part of mechanical engineers; but as seen from my standpoint, it results in this way. A purchasing agent sends to me for a price on a lot of firebox steel or boiler steel to meet the specifications of his railroad, and thinking first of the reputation of Park Brothers & Co., I say, you ought to have a 4½-cent steel. The next salesman, perhaps not representing a mill that has equal facilities, or for some

other reason feeling at a disadvantage, will recommend to the purchasing agent 3½-cent steel, and then along will come a salesman who will take that order and agree to meet those specifications on a 3-cent steel.

Well, now, that would result all right for the 4½-cent man, but, unfortunately, the 3-cent steel will pass those specifications and will be used by the railroad almost every time. Then the next time that the 4½-cent salesman comes to figure on the specifications with the purchasing agent, who, of course, is supposed to protect the interests of the railroad company, he tells him that he can buy a steel that meets their requirements for much less money. He may not give the price away, but he indicates that it is in the neighborhood of 3 cents a pound. Now, what the purchasing agent saves in his department is added on the repair account of the mechanical department, but it takes time to demonstrate that. So that as this question has been brought up by the railroad companies, I believe that it would not be out of place for me to say that they will never find any improvement by following this policy of thinking that these specifications are the only safeguard. I don't believe that you can improve the material on a railroad by having an individual watch, so to speak, on steel manufacturers, because if that steel meets the specifications, no matter what the price is, the steel manufacturer escapes all the responsibility and he puts it on the railroad company. But I believe that there are in this country several steel manufacturers that can be trusted. I believe that if the railroads were to pick out a few of the reputable concerns and ask them to make a plate of steel on honor at a price—say a price of 4½ cents a pound—that they would greatly strengthen their own position and would place the steel makers on their pride.

Mr. Vauclain—We buy a great deal of steel. I would be very glad if the young man would tell us how we are going to tell the disreputable makers of steel.

The President—Will Mr. Jackman reply to the question?

Mr. Jackman—Well, that of course is for the railroad companies to decide. But this fact seems to be before us, that we have testimony here from large railroads that steel that was made years ago gave longer service than steel that is being made now, as a rule.

Mr. Barnes—Steel that was put in eighteen years ago has had eighteen years to show itself. But I do not see how steel that was put in five years ago could show eighteen years of service. I think there is no point to the matter at all.

Mr. Wm. Forsyth—I would like to give an illustration of how far we can trust a most reputable steel manufacturer without following up with a careful watch on physical tests and chemical examination. From what Mr. Jackman has said, I should question very much if he could name a railroad company that employed a chemist and a chemical specification to which he could ship 3-cent firebox steel. A short time ago we received a shipment of steel, and we reported to the manufacturer that there was too much sulphur in it. The chemical part of the concern questioned our method of chemical

analysis and said that it was difficult to get uniform methods of analyzing steel for phosphorus and for sulphur, and perhaps our method did not agree with theirs. Well, we did not drop it with that. We took a small coupon and we analyzed it ourselves, and we sent the other piece to the steel manufacturer. A short time after that we got a reply, saying that they were very sorry to see that the steel had contained more sulphur than they intended ; that our analysis was correct, and that the reason of it was that their furnace was running with a gas too full of sulphur. (Applause.)

Mr. Blackwell—A statement was made just now that a firebox steel nowadays, as made nowadays, is not giving the same length of service as a firebox steel made some years ago. Now, I do not think it is proper to compare the service of a firebox of the present time by years with fireboxes of former years. We now easily double, and in some cases treble, the mileage per month of an engine over what we did ten or fifteen years ago. Not only that ; we are using 160 to 180 and 200 pounds of steam pressure, consequently having very much higher firebox temperature. We are using bad water in very many cases, especially in the West. I believe this is caused by cutting down the forests, which formerly had the effect of holding the rain water a certain time and feeding that rain water slowly into the streams and rivers from which the supplies of railroad tanks were taken. Now, nearly all the timber is cut down. When a rain storm comes the rain finds its way off into the rivers quickly, and after that rainfall and freshet is over, down go the rivers, and they are kept up by spring water almost altogether. Now, we all know what spring water is, as a rule. It is about the worst water we can get hold of for a boiler, and I believe that is one of the causes of our getting very much worse results from fireboxes now than we did. I think the matter of extra firebox temperature is another very serious matter which tends to reduce the life of the box. It also decreases the life of stay-bolts. As the temperature of the box is increased, expansion is increased, and there is a little more for the stay-bolt to take care of, in addition to the increased pressure.

Mr. McIntosh—I should like to say one word, and that is—that if a better quality of steel can be made by steel makers at double the price that we are paying for it now, it would pay the railroad companies to buy it, for the very reason that manufactured steel that goes into the firebox represents but a small per cent. of the cost of renewing a firebox. For that reason, if we could get steel for a considerably higher price that would last four years instead of two years, we would cheerfully pay for it, I think.

Mr. Swanston—I think this is one of the most important questions that can come up. It is one that is giving me a good deal of trouble, and I would like to hear some solution of it. The idea that I first started out with, and the idea that seems to be carried out in this discussion, is that a steel maker can fill our specifications, both chemical and physical, with a 3-cent steel and with one that costs 4½ cents, and that his profits on the steel are the same. Consequently, there is something in the work—either in the work or the material—to improve the quality of the steel and make it

answer our purpose better. Now, if we can get at some of those tests, if we can get some tests by which we could get at that quality of steel which will give us the best service, that is what we want.

Mr. SMITH—Since our last meeting the proprietors of three of the steel mills of this country told me personally that they were not making the best steel—they were not getting the price for it. One steel maker told me that he would require 5½ cents a pound to make first-class steel. Now, if such is the case, what is the use of our specifications, either chemical or physical?

Mr. VAUCLAIN—I think 5½ cents would not only enable the manufacturers to make good steel, but also to make a very large fortune in a very short time. You can put the best Scotch steel on the wharf in this country for less money—a great deal less money—than the ordinary selling price of steel in this country to-day, and when you come to talk about 3 cents and 4 cents and 5 cents and 5½ cents for steel, there is no reason for those prices at all. I think that steel makers could manufacture a good steel to any specification and could guarantee it for the very lowest price now paid for steel.

Mr. SMITH—I would like to ask Mr. Vauclain how long they would guarantee steel?

Mr. VAUCLAIN—We have guaranteed fireboxes for five years. We have engines in service now that are guaranteed for five years.

Mr. SMITH—We have 900 engines. Do you suppose we could renew the fireboxes every year for those 900 engines?

Mr. VAUCLAIN—You say you have renewed them in six months.

Mr. SMITH—We have had cases where we have renewed them in less time than that.

Mr. VAUCLAIN—We take it for granted that five years would be the average life of the firebox the way engines are used as they are to-day, continuously. Where engines are supposed to be washed out with warm water, nine times out of ten the water is nearer cold than hot. The firebox is subjected to strains that it should not be subjected to under any consideration whatever. In consequence of which we have a great many failures from that cause, which the master mechanic in charge of the road is at a loss to account for, simply because subordinates have not properly heated the water that they wash the boilers out with.

Secretary SINCLAIR—There is one point I wish to speak on in regard to this discussion. There seems to be a great tendency to talk of the life of the firebox by years. That seems to be a very incorrect method of comparison. On one road you find engines not making more than a thousand miles a month, and on others you will find them making four or five times that. The right method of comparison ought to be the water evaporated by the firebox. That is really what is the trial of the firebox endurance—the heat units that have passed through it. It really ought to be a mileage basis or a water evaporation basis that should be taken for the life of steel.

Last year, when Mr. Hill was in Leeds, England, he saw some very

interesting experiments made with tests of steel. I think the meeting would be very much interested in hearing some particulars about those tests.

Mr. John A. Hill—I think that Mr. Fox himself is here. I would like to hear from him. I think Mr. Fox could talk to us on steel tests and specifications in a way that would be exceedingly interesting.

The President—Mr. Fox, I believe, is not here.

Mr. Hill—I do not think I could interest the members here by describing what I saw. I would simply say that the tests of lamination that I noticed in Mr. Fox's works were like this—a sheet when rolled was drawn out on to a cooling table and the man got down with his eyes lengthwise with the sheet, and when a black spot showed he chalked it. I asked what he was doing. He said he was looking for lamination ; that the lamination would cool quicker than the rest of the sheet. They cut off about a third of the bloom in every case. We all know the top of the bloom is very porous and, when rolled out, the bubbles that are there will roll into a pipe. No maker can, I believe, take a bloom and make it all up into good firebox steel. The lower half of the bloom is always more dense than the upper half.

Mr. Leeds—I would like very much to hear from Mr. Fox. You will remember there was some objection to his speaking in the Master Car Builders' Association on account of his being the patentee of a truck. But I understand he has made several speeches in this country on general mechanical practice and engineering practice, and that he has in every instance kept away from the subject of his patent and given a very good talk.

Before I sit down I would like to say to Mr. Sinclair and the other gentlemen, that these engines I speak of have made a great deal of mileage. In 1883, for two months, eight of them made an average of 13,500 miles a month, and since then they have made an average of about 7,000 miles per month. One of our superintendents has several of them on his division and he says that some of them are making as high as 11,000 miles.

The President—Mr. Lewis, can we hear from you on this subject?

Mr. Wm. H. Lewis—I do not think, Mr. President, that I can say anything more than what has already been said. But while not wishing to underrate the value of the physical and chemical tests that we subject steel to, I think that we cannot entirely ignore the suggestion of the Committee about additional tests having for their object insuring a higher degree of quality than the ordinary test that is now used. We all know that it requires not only knowledge, but skill, in all business, and in the manufacture of steel you can put the ingredients into the hand of a man and say: "This steel is to be made so and so. You go to work and make a steel plate." That man cannot do it unless he has the steel to do it, which is only acquired by experience, and any suggestions that are thrown out by the Committee which will raise the standard of tests I think should be seriously considered.

Mr. Mitchell—There is one question I would like to ask. I was told by a traveling man for a steel company that the proper way to find lamina-

tions was to heat the steel to a blue heat, nick it and bend it, and that would develop the laminations quicker than otherwise. I would like to know if such is the case.

Secretary SINCLAIR—Mr. Sargent, who is sitting there, is an old engineer of tests. Perhaps we may get some information from him.

Mr. SARGENT—In regard to detecting laminations in steel, I have always found that an examination of the fracture of a tensile test will show whether there is any lamination in that, and from that we go to the sheet, and we almost always find the laminations extending into the sheet, and we throw out that sheet accordingly. I think careful examination of the sheet in the store house, careful inspection, will very often show blisters and laminations which the ordinary examination, which is common among railroads, will not show. But careful inspection following the tensile test will develop a great many of the bad sheets.

Mr. SETCHEL—This is a subject in which I am very much interested. I cannot do, as some members do, sit down, after speaking, and be satisfied that what they have stated is exactly so, and assume a satisfied air. I do not believe that there is any chemical test that will suit all localities. I think it can be illustrated by the practice of two-thirds of the master mechanics in this room that they have locomotives that under certain conditions, running with certain water, will run their firebox for years under the modern practice of five or six or seven thousand miles a month. There are roads using equally good steel, made by the same manufacturers, that will not run three years, with exactly the same chemical test. I have had the experience of having Lowmoor iron fireboxes running twenty-three years, the most of the time burning coal, without any laminations or fractures whatever. I am satisfied that these fireboxes placed on a road where they were using impure water would not run any time at all. We have never had much trouble, in our experience, about fireboxes laminating. We have only two cases in the last five years that I know anything about. In one of those cases, four of the engines, made of exactly the same kind of steel, but running in a different locality, and with different water, have given the best of satisfaction—no signs of cracking or lamination whatever. While other engines made at the same time, running in another section of the country, show not lamination but fractures—cracks around the staybolts. So far as the trouble from lamination is concerned, we have but one case, where pure water is used, that the trouble has occurred by the lamination of the firebox. In the days when our old member, Mr. Hayes, used to make reports on firebox steel (some of the older members will remember he was chairman of that Committee for a great many years), you will remember that in his reports he had a great deal of difficulty about keeping steel in crown sheets, while in every other part of the boiler he had no trouble whatever.

But those times, Mr. President, are not to be compared with the times now, in periods of months or years, when we are estimating the lives of fireboxes. Engines do harder work now. They carry higher pressure than

they did before, and if they wear out quicker we must expect it, and we must know that it is the work done. It is not the years that have gone by, but it is the work that those engines have done—the tons that they have hauled. That is the test of fireboxes, that is the test of locomotives, with the same kind of surroundings, but they must have the same water. There is a very great difference, too, in localities where they use brick arches. That makes a difference, and under the same treatment you will get different results where brick arches are used. Now, Mr. President, I do not believe that it is possible for a chemical test to satisfy all localities and all conditions of water, because we have seen that the very best of Otis steel in some sections has failed to give three years' service, while in others it has given twelve or thirteen years' service.

Mr. BARNES—I was on the Committee last year, and we devoted a good deal of time to finding out what caused lamination, and we could not find one cause that did not rest with the steel makers themselves, and I know the decision was, in some discussion I had with steel makers, that they could not tell me how I could tell whether a sheet was laminated in the middle or not. If it was laminated in the edge I could find it, but in the middle I could not, and the steel makers agreed with me that the specification was not entirely responsible for lamination, because the laminations mostly came from improper pouring of the ingot. It may give cast bubbles. It may make small or local lamination. There may be a chill on one side, or in pounding the ingot under the hammer they make one blow stronger than another and make a shoulder, and in rolling it this shoulder rolls out as a film over the plate. Therefore, when the specification was drawn up the makers of the steel agreed not only to furnish new steel, but to put it in the fireboxes, and pay all the expenses of putting them in, which is something unusual, and the latter part is by far the greater part of renewing fireboxes. The fireboxes have not shown any lamination so far, and the fires have been so hot that if there has been any lamination in there they would have shown it.

Mr. MCINTOSH—I wish to call attention to the fact that lamination is encountered but very slightly in practice. I presume 90 per cent. of the failures are from cracking instead of lamination. In fact, I do not know of a case of failure from lamination that has come under my observation against thousands from cracking.

Secretary SINCLAIR—I was just going to say, after I heard Mr. Barnes' remarks, that I think steel makers could well afford to guarantee sheets for twenty years against lamination. I was some six or seven years working among a hundred engines where we had very bad water, and I never once heard of a case of failure from lamination of the steel firebox.

Mr. BLACKWELL—I would like to ask Mr. Barnes how he expects the lamination to show itself in the firebox. He has not seen any of it yet. How does he expect it to show itself?

Mr. BARNES—By a blister which leads to a crack.

Mr. BLACKWELL—I think it is quite safe to say there may be very seri-

ous laminations in sheets and they will not show in the shape of blisters, unless the lamination is very near the surface.

Mr. BARNES—I will have to retaliate and ask Mr. Blackwell where I shall look for it.

Mr. SETCHEL—I would like to ask one question : I would like to know how many members there are here running steel fireboxes that have had laminations in their fireboxes? It seems to me that that is not the trouble at all. I have heard of but very little trouble from lamination.

Mr. SMITH—My recollection, with respect to the engines that we have, is that I have seen only one, which was a small one.

Mr. GENTRY—I would state our whole trouble is almost exclusively from cracks.

Mr. SMITH—That is our trouble, too.

Mr. GENTRY—And they are not located at any one particular spot. Our boxes are very uniform, of a certain standard of engine, and we found that those cracks develop at first one place, sometimes a side sheet, sometimes a back sheet, sometimes a throat sheet. We have had more side sheets near the door than anywhere else. As to the laminated fireboxes, they have not developed yet.

Mr. BLACKWELL--What causes the cracks from the stay-bolts? I should say, overheating the sheets. The effect of lamination is to cause those sheets to be overheated. Lamination forms a barrier, to a certain extent, to the free passage of heat from the firebox side of the sheet to the water. The greater the lamination the larger the number of plates in the thickness of the sheet, so many more barriers to the free passage of the heat and the greater the temperature of the sheet will be raised. Lamination acts in that way as a very serious reducer of length of service of the plate, in causing the sheet to act as a bad conductor of the heat. It consequently becomes overheated and fails from cracking a great deal sooner than it should.

Mr. DAVID BROWN—In the neighborhood where I am from we have a pretty hard road to run on—a mountainous road. We find, with engines that have light work to do, that they have very little trouble with their fireboxes. For instance, take a switching engine ; we have fireboxes in those engines that have been running since 1876, for the simple reason that they are not abused. Again, we have had passenger engines before we widened the fireboxes over the frames into which we put the third firebox in five years. It was the hard work the engine had to do. Since then we have gone into the Wootten firebox. They are of easy draft, and we never have any trouble with them as regards sheets. I have come to the conclusion that it is the heat and the hard service that the locomotives are put to that gives us the trouble. As regards the lamination, we have not had much trouble with that. I have seen the sheet blister probably half way, and I have raised it up and chipped it out and have had no further trouble with it.

Secretary SINCLAIR—A member asks the question : "Is the Presence of

the Brick Arch Liable to Make Cracking of Sheets More Frequent than Without the Arch?"

Mr. GENTRY—We have had considerable experience with coal-burning engines, but we commenced using the arch about four years after we first commenced burning coal, and I do not think that we have had any more trouble. It is just possible that our trouble of cracking near the door may have been due, somewhat, to the arch, as it brings the flames and gases back there much further than they would go without it. We have not had much trouble with crown-sheets. Fewer crown-sheets crack than any other part of the firebox. When our sheets crack, they crack, as a rule, from the stay-bolt. One commences to run out and runs from one bolt into the other, and if there is any lamination in any of those sheets we have been unable to discover it, even under a glass. We had the sheets broken right through these fractures, so that we could see if there was any lamination in the sheets. Apparently they were solid fractures in a perfect sheet.

Mr. GILLIS—It might be interesting to know that Edison has gotten up a patent, which has been working successfully, to determine laminations in a sheet by the resistance to the electric current. I do not see why it would not be a thoroughly practical and very good way of determining lamination in steel sheets.

Mr. BARNETT—Mr. President, I would like to ask what your experience has been. You have as wide a range of waters as any road in this country.

The PRESIDENT--My experience with cracked sheets has been the same as the rest of the members. I attribute it mostly to hard work and bad water and high temperature of the firebox. I could give the members no detailed information on that without going into greater length.

A MEMBER—I move to close the discussion.

Mr. MACKENZIE—I think we ought to continue this matter either with the same Committee or by substituting another Committee, and that it be recommended to the Committee that they report at the meeting of this association next year the proper chemical analysis and physical test that should be used as the standard of the Master Mechanics' Association.

Secretary SINCLAIR—It is practically a new subject that Mr. Mackenzie proposes, and it would be a good way to hand it in to the Committee on Subjects. It has been found very undesirable practice to continue Committees. A new Committee works more energetically than one that is continued a second year. It would be a much better plan if you let this Committee be discharged and bring up the new subject with the Committee on Subjects.

Mr. MACKENZIE—I agree to that.

The motion to close the discussion was carried.

Mr. MACKENZIE—I move that we adjourn, with the understanding that we take up the question of compound locomotives the first thing to-morrow morning.

The motion to adjourn was carried.

SECOND DAY.

The Convention was called to order on Tuesday, June 20th, at 9:15 A. M.

The PRESIDENT—We are now in possession of the report of the Auditing Committee, which Mr. Pomeroy will read.

Mr. POMEROY read the report of the Auditing Committee, as follows:

REPORT OF AUDITING COMMITTEE.

Your Committee, appointed to audit the accounts of the secretary and treasurer, beg leave to report that they have fulfilled their duties and have found the accounts correct.

A. E. MITCHELL,
P. LEEDS,
J. H. SETCHEL,
Auditing Committee.

June 19, 1893.

Mr. LEWIS—I move that the report be received and placed on file.

The motion was carried.

The PRESIDENT—The next order of business is the report on Compound Locomotives. George Gibbs is chairman of the Committee.

Mr. LEWIS read the following report of the Committee on Compound Locomotives:

COMPOUND LOCOMOTIVES.

Your Committee, in expressing a hope one year ago that this interval would serve to clear up many of the obscure problems connected with this difficult subject, seem to have been unwarrantably confident; at least, the opinions and results of experience which they have been able to gather bear the same diversified complexion as of old. And yet they cannot fail to observe an advance towards a reasonable solution of the problem in the agreement of the advocates and the adversaries of the new departure to meet upon a common ground and leave their disputed theories to a practical time test. In reading over the lengthy discussion of this subject at last year's Convention, they cannot fail to be struck with the lack of definiteness in the data presented

(as was to be expected with so new a subject), and by the division of the speakers into two camps, each of which appeared to be sustaining some pet theory which had been unwarrantably assailed by the other. Your Committee, in last year's report, purposely narrowed their presentation of the subject to the question of the probable fuel economy of compounds in handling a varied character of freight service; they presented an elaborate series of tests made with one type of engine, and, although they were unfortunate enough not to be able to complete the tests according to the original programme, they felt that they had arrived at a tolerable approximation to the economy obtainable under special conditions, where the engines were in good repair and handled with intelligence. Although the figures of the report were not assailed, they met with little agreement in the discussion which followed, one side claiming considerably more and the other allowing less than those offered with much hesitation by the members of your Committee. In this present report they feel even more hesitation in attempting to present definite conclusions, as the data for such have been mainly drawn from a distance by correspondence, and the conditions under which they were obtained are unknown. As to the substantial advance made in the introduction of compounds since the last report, the statements received from locomotive builders in this country show good progress, as follows:

COMPOUND LOCOMOTIVES IN USE IN AMERICA.

BUILDER.	JUNE, 1892.	JUNE, 1893.
Baldwin Locomotive Works	65	316
Schenectady Locomotive Works	35	69
Rhode Island Locomotive Works	14	37
Others	..	..
Totals	114	422

In addition to above, reports show 108 compounds under construction and 75 of American manufacture in use in foreign countries.

An inspection of the geographical distribution of these locomotives reveals the fact that the great majority are running upon

roads where coal is cheap, so that their approval upon those roads means satisfactory possibilities for our Western master mechanics who have to contend with dear fuel.

Before entering upon a discussion of the problem, as it appears to your Committee to-day, they beg to present all the information they have been able to collect, in the nature of tests or figures; this is embodied in the following:

SYNOPSIS OF INFORMATION OBTAINED FROM RAILWAY COMPANIES.

The following information is abstracted from answers received by your Committee to a circular sent to various members of this association. The circular requested, particularly, practical data bearing upon experience with compound locomotives in actual service. It was stated that your Committee hoped in this way to obtain information which would shed some light upon the probable net value of compounding locomotives. They further desired "to bring out as fully as possible the advantages as well as the defects of compound locomotives, not only as regards fuel economy, but as to all other elements which go to make up a successful machine, from an operating as well as a motive-power point of view."

Quite a large number of replies were received, in the majority of which members were obliged to state that they had no experience with compounds; in others, information given was so meagre that no conclusions were deducible at a distance. Your Committee also reports absence of replies from some of our members who are known to have a considerable number of compounds in use. The following are abstracts from those giving fullest information, with comments upon the results. Your Committee hope that unwarrantable deductions will be corrected by members present representing the roads quoted, for in no case was it possible for the circulars to cover a statement of all local conditions governing the tests.

Northern Pacific Railroad.

Performance sheets record of five months' service in freight with one compound and one simple Baldwin mogul.

Engines of same dimensions, the compound having 20 pounds higher steam pressure.

Engines in service two years, having run about 60,000 miles. Records are for the last 17,000 miles of the above.

No figures for train loads given.

Compound was found to use 20.3% less coal per engine mile han the simple, and 18% more oil.

They also give results of comparative tests on ten trips, as ollows:

Percentage train hauled per pound coal, 22.2;

Percentage water evaporated per pound coal, 11.3;

oth in favor of the compound.

No data given for cost of repairs, and no opinion ventured as o probable relative standing. State they have had trouble with rregular wear of crossheads and guides.

Above submitted by them without further remarks.

Norfolk & Southern Railroad.

Performance sheets record of two months' service, with small nileage (2,400 for 35 runs), in local freight, of one compound and ne simple Baldwin mogul. Engines of same general dimenions, except that compound has 10,000 pounds more on drivers 13.3%), and 20 pounds higher pressure than simple.

Compound was new, while simple was two years old.

Car mileage and average cars per train were about the same latter 35).

Compound was found to use:

24% less coal per engine mile,

22.2% less coal per car mile.

23½% more oil than the simple.

Gives cost of repairs per mile run to be 24% more for compound, but as the compound was a new engine this figure appears o your Committee of no value.

State that their general observations indicate increased cost of epairs to compound on account of extra number of rod and iston packings, construction of crossheads and presence of special arts.

Results in passenger runs from one month's performance heets are given for two other Baldwin engines; the simple being in eight-wheel engine ten years old and the compound a heavy

mogul, the dimensions, including size of drivers and pressure, being entirely dissimilar.

Mileage is small and trains very light, 3½ to 4 cars.

Results give compound using 7% more coal per engine mile and 7% less per car mile than the simple; also, compound uses 46% more oil than the simple.

Your Committee are not advised for what purpose the above test was made; it would seem to be valueless for drawing conclusions as to economy of compound locomotives in passenger service The engines were as dissimilar as possible in type and dimensions; one was new, the other old; and the record was for small mileage and very light running conditions, as the amount of coal burned per engine mile (39 pounds) shows. It is, in fact, rather astonishing that the heavy mogul makes as good a showing as it does under the circumstances.

New York, Lake Erie & Western Railway.

Give record of special tests in ten runs of 140 miles each, f[illegible] one Baldwin ten-wheel compound and one Baldwin simple, in fa[illegible] freight service. Engines were new when tested.

Engines of the same general dimensions, the compound havi[illegible] slight additional weight (1,400 pounds, 1.2%) on drivers, and [illegible] pounds higher pressure.

The simple hauled on an average 10% longer and 13% greate[illegible] total weight of train than the compound. The results were a[illegible] follows:

Compound saved over simple—
Coal per engine mile, 15.1%;
Coal per car mile, 8%;
Coal per ton mile, 3.85%;
Water per ton mile, 4.12%.

Compound ran 20.7% further per pint of lubricating oil, and 23.2% further per pint of valve oil than the simple.

Above tests were "made with great care under as nearly similar conditions as possible and by same engineman. Several trips with compound gave much better results than the average, the low average percentages being due to the fact that it was necessary to reduce the weight of trains hauled by compound, on account of extremely unfavorable weather, track being blocked

y snow." Test of compound made in December and of simple n October.

State that cost of repairs will probably be higher for the compound in maintenance of cylinders, but say that "our boiler repairs to compound are much less than with simple engine. No epairs have been made to compound's boiler since its purchase nd flues have been constantly tight, which cannot be said of imple engine purchased at same time."

Service, apparently, 40,000 to 50,000 miles at date of report.

Chicago & Northwestern Railway.

Give results of performance sheets, figures for Schenectady imple and compound and Baldwin compound, in both freight and assenger service.

1st. Give results in freight for five simple and one compound Schenectady engines; engines same specifications, except that ompound has 4 inch larger wheels and 20 pounds higher pressure, vith a trifle less weight on drivers. Engines all new and records over six months' service, 27,000 to 36,000 miles.

Service is estimated to be about the same for all; engines running first in first out.

Results show compound to use:

7.7% less coal per engine mile and 27% less lubricating oil than he simple.

2d. Give results for a Baldwin ten-wheel compound, which nay be compared with the five Schenectady simples above; engines are on nearly same specifications, except the compound has -inch larger drivers with somewhat larger boiler and longer firebox, and 20 pounds higher pressure than the simples. Mr. Smith onsiders the comparison quite fair, however. The results show he compound [illegible] more coal per engine mile and [illegible] ess lubricating [illegible] simple.

3d. Give [illegible] passenger service for a Baldwin eight-wheel comp[illegible] eight-wheel simple; engines are not [illegible] specifications, the compound having 6.000 po[illegible] on drivers, [illegible]-inch larger boiler, with shallow [illegible] deep firebox), and [illegible] pounds higher [illegible] simple, the latter is also [illegible] years old, while [illegible] engine

Mileage, 15,000 to 23,000 miles for simple. Records are from performance sheets, and show compound to use 10% less coal per engine mile and 21.5% less lubricating oil than the simple.

Costs for repairs per engine mile are given, but they state that considerable extra work had to be done on several of the engines to get them in running shape, so that the figures given cannot be relied upon. State further that they cannot yet say whether repairs will be greater or less for compounds. They think there may be a small saving for compounds in repairs of flues, but see no other particulars in which they are likely to effect a saving. Have had some little trouble with breakage of an intercepting valve on the Schenectady, and some irregular wear on Baldwin crossheads.

In a letter accompanying data, Mr. Smith states he thinks "it will take a pretty good compound to beat a modern simple engine."

Kings County Elevated Railway.

Give records from performance sheets of average of sever simple and one Rhode Island compound engine. Record cove about 50,000 miles service, or one year. Engines are similar type; compound has 2,000 pounds (5%) greater weight on driver a slightly larger boiler and grate service, considerably great heating service and 30 pounds higher pressure than the simp engines. Hard coal is burned.

The car mileage and weight of train hauled average the sa for both engines.

Results show compound to save:

Coal per car mile, 24%;

Coal per ton mile, 24%.

Mr. Hedley considers the tests very conclusive ones, as t engines hauled the same trains and performed precisely the sa work.

No figures are given for repairs, but opinion is expressed th on the whole, repairs will be very slightly increased for the co pound, the balance being struck between increased cost of taki care of slide and intercepting valves, and marked decrease in r pairs to boiler of compound.

Cleveland, Akron & Columbus Railway.

Report figures from performance sheets covering about 40,0

miles' run of two Baldwin eight-wheel passenger engines, one simple and one compound.

According to the figures given, engines are of identical dimensions, of same weight, and both run at 180 pounds pressure.

Average train for compound was of three cars, and for simple four cars, the average weight of compound's train being 16% less than that of the simple.

Under these conditions, records show that compound saved:

Coal per engine mile, 32%;

Coal per car mile, 15%.

Oil used is given as slightly less for compound, and repairs same for both.

Mexican Central Railway.

Give results showing performance of six compounds for fourteen months, one simple engine of same dimensions for four months, six bogie engines for three years and four consolidations for five years.

State in letter that "these six compound locomotives, while comparatively new engines, have had to bear considerable expense in the way of modifications found advisable from time to time, as these engines were somewhat of an experiment."

"The Mexico, Cuernavaca & Pacific Engine No. 2, shown in second column, is a new engine built on the same lines as the compounds, with the exception of having the firebox between the frames; this gives slightly more heating surface in the firebox, and owing to the fact that 2 feet of the grate surface of the compound is taken up by the brick arch and auxiliary ash pan, it leaves the Cuernavaca engine with slightly more live grate surface than the compounds."

Quoting further from Mr. Johnstone's letter, he says: "From our experience with these compounds, I am led to believe that repairs to boiler and machinery will always be so much lighter than with simple engines doing the same work, as to quite offset the additional repairs made necessary by the number of parts about the cylinders and pistons, and, therefore, the total cost of repairs will compare favorably with simple engines doing the same work. The general belief is that compound engines must use more oil than simple engines, but the performance of these six

compounds goes to show that such is not the case. Being of the opinion that these engines would require more valve oil, I did not limit the engines in its use, and I am surprised to see the results as shown. Engineers claim they have used all they found necessary, and this seems to have been the case, as we find the cylinders and valves in perfect condition when uncovered after a year's service. With these figures before us and with my knowledge of the ease with which these engines are performing their work, I feel confident in claiming that the economy effected in total expenses will be from fifteen to twenty per cent. over engines of exactly the same dimensions and weight."

Below will be found detailed statement of performance of these engines as prepared by Mr. Johnstone :

Norfolk & Western Railroad.

Comparative tests made in passenger service of a Baldwin compound ten-wheel engine and a Rogers ten-wheel simple engine. Engines of similar type, the compound having 5,000 pounds more on drivers (5 [illegible]), 8-inch larger drivers and 35 pounds higher pressure than the simple engine, the compound being a new engine and the simple two years old. No remarks made as to conditions and results, but as latter were worked out with care and fullness, it is presumed that conditions were similar. Tests were made with each engine on four different trains. Average results are given, as follows, in percentage of economy of compound over simple :

Coal per ton mile, 13.4 % ;
Coal per car mile, 20.4 % ;
Water per ton mile, 8.0 % ;
Water per car mile, 10.3 %.

Cincinnati, New Orleans & Texas Pacific Railway.

Extensive tests made under the supervision of a member of your Committee, of two Baldwin ten-wheel passenger compounds and one simple, the latter being three years old and the former new. The engines were of similar type, the compound, however, having about 5,000 pounds more on the drivers (6.2%), a larger boiler, 10 % more heating surface and 6-inch larger driving-wheels than the simple. Steam pressure not given.

Results given for ten runs with each engine of about 100 miles

each. The compound had about 2% heavier trains and hauled 3% more car miles. Average speed, same for both.

Saving for compound was as follows:

Coal per engine mile, 33.7%.

Coal per car mile, 35.5%.

Coal per ton mile, 35.2%.

Evaporation per pound of coal, 28.7%.

Mr. Meehan comments upon the much more efficient evaporation obtained with the compound than with the simple, saying that the former was much cleaner and threw fewer sparks. Also states that indicator cards show the greater proportion of work in the compound is performed in the low pressure cylinders.

Cannot tell yet the expense of repairs with the compound, but believes it will be greater than with the simple, reciprocating parts being heavier. Believes some part of higher percentage of economy shown above is due to larger heating surface of compound.

In final summing up, expresses very positive belief in the large economy and varied usefulness of compounds.

Chicago, Burlington & Quincy Railroad.

At the February, 1893, meeting of the Western Railway Club, Mr. Wm. Forsyth presented some elaborate tests of compound and simple engines in fast passenger service. The engines were of different types and unlike in weight, capacity, boilers, cylinders, etc., and the tests were not made to establish the comparative value of simple and compound engines, but rather to develop the best type for the particular service met with on that road. As this interesting paper has been widely published and discussed, it is not necessary to detail the results here further than to give some of the general conclusions deduced by Mr. Forsyth.

These are:

1st. The average rate of evaporation was 5% more with the simple than with the Baldwin ten-wheel compound.

2d. The cylinder performance measured by the indicator cards, taken at average running speed, forty-five miles per hour, shows 18% more foot-pounds of work done per heat unit in the steam used by the simple engines than by the Baldwin compound.

3d. At thirty miles per hour the cards show the Baldwin engine to have the best economy, developing 14% more work per heat unit than the simples.

4th. The poor showing made by the Baldwin compound was largely due to the heavy train and high speed. With a lighter train, or the same train on a lower schedule, it would have shown a much better economy. The cards taken at thirty miles per hour show this.

5th. The Baldwin compound engine, as operated on the C., B. & Q. R.R. on trains 1 and 6, weighing 350 to 400 tons, was not as economical in the use of coal as the C., B. & Q. simple "H" engines by about 25%. When worked in heavy express service the Baldwin compound, 82, lost the principal advantages of compounding, namely:

A. High initial pressure in the cylinders.

B. Increased number of expansions.

C. Softer blast on fire.

As a result its boiler performance and cylinder performance were not as good as simple engines of proper capacity.

In letter they state they do not believe the time has come to draw proper conclusions as to the net value of compounds. Believe any new type has weak points which can be corrected by experience. Think there would be an advantage in compounds on account of less trouble from hot driving-boxes (presumably on account of more uniform turning moment of this type), at least that is their experience so far with the two types of same class.

They prefer the simplest possible design of starting mechanism, and commend the Lindner valve for this purpose.

Pennsylvania & Northwestern Railway.

Give performance sheets records of eight Baldwin consolidation compounds and eight same simples.

Engines of same design and general dimensions, but compounds having 9,000 pounds more on drivers and carrying 45 pounds higher pressure than simples.

Table No. 14, below, gives compilation of results furnished your Committee.

Chicago, Milwaukee & St. Paul Railway.

Your Committee presented last year results of tests of a Baldwin ten-wheel freight compound, compared with an exactly similar simple. Since that time these engines have been in regular service, and the following tables Nos. 1 to 13, inclusive, have

CHICAGO, MILWAUKEE & ST. PAUL RAILWAY.—PERFORMANCE OF TEN CLASS "D" LOCOMOTIVES.

Engine No.	Engineman.	Miles run.	Total coal.	Miles to 1 ton coal.	Pounds coal per engine mile.	Repairs per mile, in cents.	Miles to pint of machine and valve oil.	Miles to pint of valve oil.	Standing of Engine No. 827 (compound). Miles per ton of coal. 1st greatest.	Pounds per eng. mile. 1st least.	Repairs. 1st least.	Miles per valve oil. 1st least.
818	McGeen......	1,833	101.8	18.01	111.0	1.93	7.90	29.58	1st.	1st.	5th.	10th.
819	O'Connor....	3,114	132.0	23.59	84.7	2.90	12.30	52.77	......	......	......	......
820	Cowper......	4,608	171.8	26.82	74.5	1.68	9.00	45.17	......	......	......	......
821	Barrett......	3,553	141.6	25.09	79.7	1.13	15.72	71.06	......	......	......	......
822	Gebhardt....	3,851	153 4	25.10	79.6	1.09	11.92	43.77	......	......	......	......
823	Fidlin.......	3,532	153.4	23.02	86 5	1.61	12.65	53.51	......	......	......	......
824	Clarey.......	3,979	160.0	24.87	80 4	89	13.98	50.36	......	......	......	......
825	Gregg.......	3.553	158.4	22 43	89.1	2.56	11.54	44.97	......	......	......	......
826	Gale........	4,185	178.8	23.41	85.4	1.43	12.13	49.24	......	......	......	......
827	Rusch.......	3,601	121.9	29.54	67.7	1.66	12.29	41.39	......	......	......	......
Average, excluding engine 827.........		3,579	150.1	23.59	85.7	....	11.90	48.94	......	......	......	......
Saving for engine No. 827...............		......	......	25%	21%	....	3%	......	......	......	......	......
Saving for engine, simple............		......	......	......	....	....	......	18%	......	......	......	......

La Crosse Division. TABLE No. 2. *Date, July, 1892.*

CHICAGO, MILWAUKEE AND ST. PAUL RAILWAY.—PERFORMANCE OF TEN CLASS "D" LOCOMOTIVES.

Engine No.	Engineman.	Miles run.	Total coal.	Miles to 1 ton coal.	Pounds coal per engine mile.	Repairs per mile, in cents.	Miles to pint of machine and valve oil.	Miles to pint of valve oil	Standing of Engine No. 827 (compound). Miles per ton of coal. 1st greatest.	Pounds per eng. mile. 1st least.	Repairs. 1st least.	Miles per valve oil. 1st least.
818	Dwyer......	4,498	203.5	22.10	90.48	62	13.97	53.54	3d.	3d.	10th.	10th.
819	O'Connor....	4,123	150.2	27.45	72.85	1.30	10.88	54.97	......	......	......	......
820	Cowper......	4,239	144.1	29.42	68.09	1.37	9.16	51.07	......	......	......	......
821	Barrett.......	4,217	167.8	25.13	79.58	1.00	12.33	61.11	......	.....	......	......
822	Gebhardt....	4,163	163.4	25.48	78.50	57	13.78	56.25	......	......	......	......
823	Fidlin	4,263	195.8	21.77	91.86	90	12.50	51.98	......	......	......	......
824	Clarey.... ..	3,995	170.0	23.50	85.16	1.11	12.22	49.32	......	......	... ..	......
825	Gregg	4,537	192.5	23.57	84 85	1.59	14.05	56.71	.....	......	......	......
826	Gale.........	4,348	165.0	26.35	75.90	69	14.59	58.62	......	.....	......	.....
827	Rusch.	3,270	122.6	26.67	75.00	2.73	10.09	34.06	......	......	......	......
Average, excluding engine 827........		4,266	172.5	24.47	80.81	....	12.61	54.84	. ....	......	.	......
Saving for engine No. 827............ ...		......	......	7%	7%	....	......	......	......	......	......	......
Saving for engine, simple....		......	......	......	......	....	[illegible]	[illegible]				

La Crosse Division. TABLE No. 3. *Date, August, 18 2.*

CHICAGO, MILWAUKEE & ST. PAUL RAILWAY.—PERFORMANCE OF TEN CLASS "D" LOCOMOTIVES.

Engine No.	Engineman.	Miles run.	Total coal.	Miles to 1 ton coal.	Pounds coal per engine mile.	Repairs per mile, in cents.	Miles to pint of machine and valve oil.	Miles to pint of valve oil.	Standing of Engine No. 827 (compound). Miles per ton of coal. 1st greatest.	Pounds per eng. mile. 1st least.	Repairs. 1st least.	Miles per valve oil. 1st least.
818	Dwyer.......	3,462	154.0	22.48	88.96	2.59	11.03	50.91	1st.	1st.	1st.	10th.
819	O'Connor....	3,811	152.4	25.01	79.97	2.43	13.37	54.40	......	......	......	.....
820	Cowper......	4,540	176.0	25.79	77.53	95	9.30	45.30	......	. .	......	......
821	Barrett......	4,113	165.3	24.88	80.57	1.46	12.39	56.34	......	......	......	......
822	Gebhardt....	4,499	171.0	26.31	76.01	1.29	12.64	48.90	......	......	......	......
823	Fidlin.......	4,140	187.4	22.09	90.53	1.32	11.86	52.40	......	......	......	......
824	Clarey.......	4,279	173.4	24.68	81.04	1.03	12.37	53.40	......	......	......	......
825	Gregg... ...	3,732	169.4	22.03	90.74	1.78	10.31	48.47	......	......	......	......
826	Gale........	4,429	188.6	23.48	85.05	1.00	12.37	50.33	......	......	......	......
827	Rusch.......	4,354	148.5	29.31	68.21	94	12.84	38.87	......	......	......	......
Average, excluding engine 827.........		4,112	170.8	24.08	83.38	....	11.74	55.48	......	......	......	......
Saving for engine No. 827...............		......	......	22%	11%	. ..	9%	......	......	......	......	. ....
Saving for engine, simple............		......	......	.....	......	....	......	43%	......	......	......	......

La Crosse Division. **TABLE No. 4.** *Date, September, 1892.*

CHICAGO, MILWAUKEE & ST. PAUL RAILWAY.—PERFORMANCE OF TEN CLASS "D" LOCOMOTIVES.

Engine No.	Engineman.	Miles run.	Total coal.	Miles to 1 ton coal.	Pounds coal per engine mile.	Repairs per mile, in cents.	Miles to pint of machine and valve oil.	Miles to pint of valve oil.	Standing of Engine No. 827 (compound).			
									Miles per ton of coal. 1st greatest.	Pounds per eng. mile. 1st least.	Repairs. 1st least.	Miles per valve oil. 1st least.
818	Dwyer.......	4,751	218.8	21.70	92.10	1.21	14.22	56.55	1st.	1st.	8th.	10th.
819	O'Connor....	4,268	187.5	22.76	88.12	96	13.35	63.70	......	......	......	.....
820	Cowper......	3,787	180.5	20.98	95.32	1.53	13.10	55.69	......	......	......	......
821	Barrett......	3,741	163 9	22.82	90.29	84	16.93	65.44	......	......	......	......
822	Gebhardt....	4,608	195.9	23.52	85.02	1.44	14.49	61.94	....	......	......	......
823	Fidlin.......	4,319	193.4	22.33	89.52	75	12.45	57.58	......	......	......	......
824	Clarey.......	4,211	186.6	22.57	88.62	1.08	13.41	58.48	......	......	......	......
825	Gregg......	4,904	220.9	22.20	90.08	1.65	10.71	55.10	.....	.....	......	......
826	Gale.........	3,603	163.3	22.06	90.64	2.06	11.40	50.74	......	......	......	......
827	Rusch.......	4,244	155.5	27.29	73.27	1.63	12.98	42.01	......	......	......	......
Average, excluding Engine 827.........		4,244	190.1	22.33	89.97	...	13.34	58.36	......	......	......	......
Saving for engine No. 827		......	......	22%	19%	....	......	......	......	......	......	......
Saving for engine, simple.............		......	......	......	......	....	3%	39%	......	......	......	......

La Crosse Division. Date, October, 1892.

TABLE No. 5.

CHICAGO, MILWAUKEE & ST. PAUL RAILWAY.—PERFORMANCE OF TEN CLASS "D" LOCOMOTIVES.

Engine No.	Engineman.	Miles run.	Total coal.	Miles to 1 ton coal.	Pounds coal per engine mile.	Repairs per mile, in cents.	Miles to pint of machine and valve oil.	Miles to pint of valve oil.	Standing of Engine No. 827 (compound). Miles per ton of coal. 1st greatest.	Pounds per eng. mile. 1st least.	Repairs. 1st least.	Miles per valve oil. 1st least.
818	McGeen.....	4,113	268.6	15.31	128.17	70	12.89	58.76	1st.	1st.	10th.	10th.
819	O'Connor.....	4,437	221.5	20.03	99.84	67	12.57	51.00	......	......	......	......
820	Farrington...	4,179	198.3	21.07	94.95	1.64	11.58	55.58	......	......	......	......
821	Barrett.......	3,816	168.0	22.71	88.05	1.68	13.39	57.81	......	......	......	......
822	Gebhardt....	4,499	209.9	21.43	94.35	74	12.33	53.55	......	......	......	......
823	Fidlin........	4,502	196.0	21.45	93.15	96	11.98	56.81	......	......	......	......
824	Clarey.......	3,907	181.2	21.56	92.70	1.18	11.95	50.74	......	......	......	......
825	Gregg........	4,577	197.4	23.19	86.25	1.59	10.57	54.48	......	......	......	......
826	Gale.........	4,191	206.5	20.30	98.56	1.24	11.45	49.30	......	......	......	......
827	Rusch......	3,336	143.5	23.25	86.03	1.95	10.11	35.49	......	......	......	......
Average, excluding engine 827........		4,214	205.3	20.78	97.34	....	12.08	54.23	......	......	......	......
Saving for engine No. 827..............		......	......	12%	12%	....	....	......	......	......	......	......
Saving for engine, simple............		......	......	......	......	....	19%	53%	......	......	....	......

La Crosse Division. **TABLE No. 6.** *Date, November, 1892.*

CHICAGO, MILWAUKEE & ST. PAUL RAILWAY.—PERFORMANCE OF TEN CLASS "D" LOCOMOTIVES.

Engine No.	Engineman.	Miles run.	Total coal.	Miles to 1 ton coal.	Pounds coal per engine mile.	Repairs per mile, in cents.	Miles to pint of machine and valve oil.	Miles to pint of valve oil.	Standing of Engine No. 827 (compound)			
									Miles per ton of coal. 1st greatest.	Pounds per eng. mile. 1st least.	Repairs. 1st least.	Miles per valve oil. 1st least.
818	McGeen......	4,883	253.3	19.28	103.75	2.02	13.83	69.75	2d.	2d.	3d.	10th.
819	O'Connor.....	4,506	197.4	22.83	87.61	90	14.68	61.14	......	......	......	......
820	Farrington..	4,546	236.3	19.24	103.95	1.27	12.15	60.61	......	......	......	......
821	Barrett.......	4,587	230.9	19.86	100.67	53	11.53	57.33	......	......	......	......
822	Gebhardt ...	4,690	231.3	20.28	98.52	1.61	13.55	63.37	......	......	......	......
823	Rusch........	4,245	209.6	20.25	98.75	4 73	9.52	46.64	......	......	......	......
824	Clarey	4,415	214.9	20.54	97.34	2 60	15.77	74.82	......	.....	......	......
825	Gregg........	4,583	217.7	21.05	95.00	2.19	12.62	63.65	......	......	......	......
826	Dwyer.	4,815	200.5	24.01	81.20	1.23	12.67	61.73	......	.....	......	......
827	Fidlin	4,792	208.1	23.03	86.85	1.01	14.01	50.44	......	.....	......	......
Average, excluding engine 827..		**4,586**	**221.3**	**20.82**	**96.31**	....	12.92	62.12	....	......	......	......
Saving for engine No. 827...............		......	....	**10%**	**10%**	....	8½%	......	......	......	......	......
Saving for engine, simple............		.....	......	......	......	....	......	23%	......	......	......	......

La Crosse Division. TABLE NO. 7. *Date, December, 1892.*

CHICAGO, MILWAUKEE & ST. PAUL RAILWAY.—PERFORMANCE OF TEN CLASS "D" LOCOMOTIVES.

Engine No.	Engineman.	Miles run.	Total coal.	Miles to 1 ton coal.	Pounds coal per engine mile.	Repairs per mile, in cents.	Miles to pint of machine and valve oil.	Miles to pint of valve oil.	Standing of Engine No. 827 (compound).			
									Miles per ton of coal. 1st greatest.	Pounds per eng. mile 1st least.	Repairs 1st least.	Miles per valve oil. 1st least.
818	Henerty......	4,420	284.4	15.54	128.68	2.16	11.72	56.66	7th.	7th.	8th.	10th.
819	O'Connor.....	4,667	219.9	21.22	94.23	1.78	13.41	53.64	......	......	......	......
820	Farrington...	4,225	225.1	18.77	106.55	76	11.51	53.48	......	......	......	......
821	Barrett.......	1,944	88.0	22.09	91.04	....	13.50	62.70	......	......	......	......
822	Gebhardt	4,610	216.6	21.28	93.96	85	13.32	59.10	......	......	......	......
823	Rusch........	4,242	214.4	19.79	101.08	91	10.88	58.91	......	......	......	......
824	Clarey	4,680	226.4	20.67	113.84	68	12.18	53.18	......	......	......	......
825	Gregg	4,208	199.3	21.11	94.72	1.39	9.75	50.09	......	......	......	......
826	Gale.........	3,850	195.7	19.67	101 66	2.26	12.83	64.16	......	......	......	......
827	Fidlin........	3,968	208.9	19.00	105.29	1.97	10.61	38.42	......	......	......	......
Average, excluding engine 827.... ...		4.094	207.8	20.02	102.86	....	12.12	56.88	......	......	......	......
Saving for engine No. 827..............		....	......	......	......	....	......	......	......	......	......	......
Saving for engine, simple............		....	......	5%	2%	....	14%	48%	......	......	......	......

La Crosse Division. **TABLE No 8.** *Date, January, 1893.*

CHICAGO, MILWAUKEE & ST. PAUL RAILWAY.—PERFORMANCE OF TEN CLASS "D" LOCOMOTIVES.

Engine No.	Engineman.	Miles run.	Total coal.	Miles to 1 ton coal.	Pounds coal per engine mile.	Repairs per mile, in cents.	Miles to pint of machine and valve oil.	Miles to pint of valve oil.	Standing of Engine No. 827 (compound).			
									Miles per ton of coal. 1st greatest.	Pounds per eng. mile. 1st least.	Repairs. 1st least.	Miles per valve oil. 1st least.
818	Henerty	3,775	203 6	18.54	107.86	1.94	11.87	53.16	7th.	7th.	6th.	10th.
819	O'Connor . .	4,135	164.3	25.17	79.46	2.32	12.23	62.57	......	......	......	......
820	Farrington...	4,157	187.8	22.14	90.35	1.60	11.36	53.98	......	......	....	......
821	Barrett.......	3,705	155.2	23.87	83.77	1.80	13.28	66 16	......	......	......	......
822	Gebhardt.....	3,159	127.1	24.85	80.69	4.55	9.03	50.14	......	......	......	.....
823	Rusch	4,187	187.6	22.32	89.61	2.76	9.20	52.33	.....	......	......	......
824	Clarey	4,260	188.5	22.60	88.49	1.03	11.36	60.85	......	......	.....	......
825	Gregg	3,454	165.1	20.92	95.53	5.30	9.62	52.33	.....	......	......	......
826	Gale	2,104	81 2	25 91	77.18	30.61	9.80	55.36*	......	......	......	....
827	Fidlin........	3,177	181.7	22 25	89.89	2.80	10.18	36.94	......	......	......	.....
Average, excluding engine 827.........		3,660	162.3	22.92	88.10	....	10.86	56.32	......	......	......	......
Saving for engine No. 827...............		...	......	......	......	....	......	......				
Saving for engine, simple		......	......	3%	2%	....	7%	52%				

*** Had heavy repairs, $1,054.51.**

La Crosse Division. | **TABLE No. 9.** | *Date, February, 1893.*

CHICAGO, MILWAUKEE & ST. PAUL RAILWAY.—PERFORMANCE OF TEN CLASS "D" LOCOMOTIVES.

Engine No.	Engineman.	Miles run.	Total coal.	Miles to 1 ton coal.	Pounds coal per engine mile.	Repairs per mile, in cents.	Miles to pint of machine and valve oil.	Miles to pint of valve oil.	Standing of Engine No. 827 (compound).			
									Miles per ton of coal. 1st greatest.	Pounds per eng. mile. 1st least.	Repairs. 1st least.	Miles per valve oil. 1st least.
818	Henerty.	2,985	147.0	20.31	98.49	9.50	11.57	56.32*	2d.	2d.	6th.	10th.
819	O'Connor	4,272	235.1	18.17	110.06	96	14.29	61.02	......	......	......	......
820	Dwyer..	3,131	159.5	19.63	101.88	2.49	12.38	63.89	......	......	......	......
821	Barrett.......	3,914	190.6	20.54	97.39	1.15	12.43	59.30	......	......	......	......
822	Gebhardt	3,120	145.8	21.40	93.46	1.43	9.57	45.88	......	......	......	......
823	Rusch.......	3,987	185.9	21.45	93.25	1.47	11.52	57.78	......	......	......	......
824	Clarey.... ..	3,875	166.5	23.27	85.93	1.06	9.31	45.58	......	......	......	......
825	Gregg..	3,585	182.5	19.65	101.81	7.87	11.24	60.76†	......	......	......	......
826	Farrington ...	2,826	148.6	19.02	105.16	12.71	10.79	65.72‡	......	......	......	......
827	Fidlin	4,008	181.7	22.06	90.66	1.52	9.54	37.81	......	......	......	......
Average, excluding engine 827.........		3,483	173.5	20.38	98.60	....	11.46	57.36	......	......	......	......
Saving for engine No. 827		......	.. . .	8%	8%	....	......	......				
Saving for engine, simple.		......	......	......	......	...	20%	52%				

* No. 818 had heavy repairs, $283.82.
† No. 825 had heavy repairs, $282.19.
‡ No. 826 had heavy repairs, $359.39.

La Crosse Division.

TABLE No. 10.

Date, March, 1893.

CHICAGO, MILWAUKEE & ST. PAUL RAILWAY.—PERFORMANCE OF TEN CLASS "D" LOCOMOTIVES.

Engine No.	Engineman.	Miles run.	Total coal.	Miles to 1 ton coal.	Pounds coal per engine mile.	Repairs per mile, in cents.	Miles to pint of machine and valve oil.	Miles to pint of valve oil.	Standing of Engine No. 827 (compound). Miles per ton of coal. 1st greatest.	Pounds per eng. mile 1st least.	Repairs 1st least.	Miles per valve oil. 1st least.
818	McGeen......	2,074	120 5	17.21	116.20	37.26	9.51	46.68*	3d.	3d.	5th.	8th.
819	O'Connor	4.049	202.5	20.00	100.02	1 32	14.36	55.46	......	......	......	......
820	Farrington...	3,730	194.2	19.21	104.12	1.32	10.45	54 85	......	......	......	......
821	Barrett.......	......	......	......	......	....	......	......	......	......	......	......
822	Gebhardt	......	......	......	......	....	......	......	......	......	......	......
823	Rusch	3,728	165.5	22.53	96.03	1.17	9.53	49.05	......	......	......	......
824	Clarey	3,647	179.7	20.29	98.54	96	11.88	53.63	......	......	......	......
825	Gregg	1,864	74 3	25.09	79.18	19.60	11.51	50.37†	......	......	......	......
826	Dwyer.......	3,512	195.4	17.97	111.27	62	11.63	53.21	......	......	......	......
827	Fidlin........	2,885	139.9	20.62	96.98	1.96	7.95	32.05	......	......	......	......
Average, excluding engine 827.........		3,229	161.7	20.33	100.77	....	11.27	51.89	......	......	......	......
Saving for engine No. 827...............		......	......	1%	4%	....	......	......				
Saving for engine, simple.............		......	......	......	......	....	42%	62%				

* Engine No. 818 had heavy repairs, $752.87.

† Engine No. 825 had heavy repairs, $365.51.

La Crosse Division. TABLE No. 11. *Date, April, 1893.*

CHICAGO, MILWAUKEE & ST. PAUL RAILWAY.—PERFORMANCE OF TEN CLASS "D" LOCOMOTIVES.

Engine No.	Engineman.	Miles run.	Total coal.	Miles to 1 ton coal.	Pounds coal per engine mile.	Repairs per mile, in cents.	Miles to pint of machine and valve oil.	Miles to pint of valve oil.	Standing of Engine No. 827 (compound). Miles per ton of coal. 1st greatest.	Pounds per eng. mile. 1st least.	Repairs. 1st least.	Miles per valve oil. 1st least.
818	McGeen......	3,682	199.5	18.45	108.36	1.65	7.75	47.20	1st.	1st.	10th.	4th.
819	O'Connor ...	4,301	218.1	19 72	111.04	84	14.62	53.09	......	......	......	......
820	Farrington...	3,990	172 4	23.14	86.41	1.27	12.35	51.81	......	......	......	......
821	Barrett.. ..	4,117	175.5	23.46	85.25	1.29	10.45	56.29	......	......	......	......
822	Gebhardt. ...	3,596	156.7	22.95	87 15	1.98	11.27	52.88	......	......	......	......
823	Cowper	4,463	238.9	18.68	107.05	1.27	13.25	58.72	......	......	......	......
824	Clarey	4,707	213.3	22.07	90.63	1.07	11.02	54.73	......	......	......	......
825	Gregg........	1,915	81.0	23.64	84.59	14.73	50.21	25.53*	......	......	......	......
826	Washburn....	4,732	201.4	23.49	84 76	1.42	15.88	70.92	......	......	......	......
827	Fidlin........	1,674	67.8	24 69	81.00	44.59	13.95	55.80†	......	......	......	......
Average, excluding engine 827		3,945	184.1	21.73	93.92	....	16.31	52.35	......	......	......	......
Saving for engine No. 827		......	......	14½%	14%	....	......	......				
Saving for engine, simple.............		.....	......	......	......	....	17%	7%				

* Had heavy repairs, $961.75.

† Had heavy repairs, $746.43.

TABLE No. 12.

CHICAGO, MILWAUKEE & ST. PAUL RAILWAY.

General average of performance of ten Class "D" engines, La Crosse Division, for eleven months, June, 1892, to April, 1893, inclusive.

Engines.	Miles per ton of coal.	Saving per cent.	Pounds of coal per engine mile.	Saving per cent.
Average of nine simple engines.....	21.99	.....	92.52	.....
One compound engine—all engineers	24.34	10.7	83.72	9.5
Compound with Engineer Rusch—5 months..........................	27.21	17.5	74.04	15.0
Average of nine simple engines—same months....................	23.15	.....	87.44	.....
Compound with Engineer Fidlin—6 months..........................	21.94	4.3	91.78	5.1
Average of nine simple engines—same months....................	21.03	.....	96.76	.....
Simple engine with Engineer Rusch—5 months........................	21.27	2.1	95.74	2.0
Average of eight other simple engines—same months.............	20.83	.....	97.56	.....
Simple engine with Engineer Fidlin—4 months	21.91	5.0	91.26	4.4
Average of eight other simple engines—same months.............	23.18	.....	87.45	.....

TABLE No. 13.

CHICAGO, MILWAUKEE & ST. PAUL RAILWAY.

Showing cost of five engines for period of fifteen months (about 55,000 miles run each), including all repairs from time engines were received from builders until receiving general shop repairs.

	Engine 821.	Engine 822.	Engine 825.	Engine 826.	Engine (compound) 827.
Miles to 1 ton of coal........	22.40	22.05	22.42	19.45	**24.84**
Miles to 1 pint of valve oil....	53.56	47.52	52.65	46.69	**39.52**
Miles to 1 pint of machine oil.	19.74	18.68	19.21	17.87	**20.95**
Repairs per miles in cents...	4.01	3.91	4.82	4.22	**4.26**

TABLE No. 14.

PENNSYLVANIA & NORTHWESTERN RAILROAD.

Date.	Engines.	Average mileage.	Average cost per mile run, in cents.				Average saving for compound.		Average cars handled.	
			Coal.	Material.	Labor.	Total.	Coal.	Total.	Loaded.	Empty.
May, 1892....	Nine simple......	1,883.1	6.47	1.54	1.55	9.58	....	....	327.6	364.1
" "	Nine compound..	2,062.2	4.74	.27	.65	5.89	24%	38%	358.7	379.2
June, "	Nine simple......	2,079.3	6.74	.87	.69	8.28	....	....	397.6	397 5
" "	Nine compound..	2,087.3	5.09	.35	.65	6.09	24%	26%	345.1	359.7
July, "	Nine simple....	2,001.0	6.24	.66	.50	7.40	....	....	344.0	360.0
" "	Nine compound..	1,722.0	5.17	.38	.50	6.04	17%	18%	292.0	320.0
August, "	Nine simple......	1,878.1	6.78	.41	36	7.57	....	....	314.1	349.7
" "	Nine compound..	1,767.6	5.39	.45	.77	6.63	20%	12%	297.2	350.2
September, "	Eight simple.....	1,456.1	5.39	.82	1.57	7.68	....	....	230.4	246.6
" " ..	Eight compound.	1,459.7	4.33	.67	1.13	6.16	20%	19%	247.8	287.2
October, "	Eight simple.....	1,609.6	7.13	1.10	.59	8.82	....	....	291.5	324.1
" "	Eight compound	1,660.0	5.70	.53	1.19	7.42	20%	16%	227.7	357.3
November, "	Eight simple.....	1,664.0	6 58	1.03	.81	8.42	....	....	285.0	315.0
" "	Eight compound.	1,791.0	5.38	.43	.74	6.54	18%	22%	284.0	354.0
December, "	Seven simple.....	1,837.7	6 29	1.09	.67	8.05	....	....	356.0	383.0
" "	Seven compound.	1,953.0	6.24	.58	.61	7.43	00%	7%	306.0	337.0
January, 1893....	Eight simple.....	1,315.0	7.58	.60	1.03	9.21	....	....	190.0	228.0
" "	Eight compound.	1,421 0	6.40	.49	.78	7.67	15%	16%	192.0	231.0
Average, 9 months	Simple...........	1,747.1	6 58	.90	.86	8.33	....	....	304.0	329.5
" "	Compound......	1,769.3	5.40	.46	.78	6.65	18%	20%	283.4	330.6
Saving in favor of	Compound......	....	18%	49%	9%	20%	....	....	.....	.....

been compiled, giving results appearing on the regular monthly performance sheets.

The tables show performance of ten engines, in which the compound, No. 827, appears. These engines are of the same class and were all built by the Baldwin company, and put in service in February, 1892. It has been thought advisable to give these results in more detail than those from other roads, for the reason that your Committee have full knowledge of the conditions and can speak more intelligently of the same than in other cases. Tables Nos. 1 to 11, inclusive, give monthly performance; the column for "Repairs per Mile" gives running repairs, except in cases noted, where figures are abnormally high, where they include "general shop repairs," which are charged to month in which they occurred. These repairs obviously destroy the month to-month average cost of "Repairs per Mile" for the entire series; for final comparison in this respect see Table 13. At foot of each table have been averaged the figures for the nine simple engines and a comparison made with those for the compound. Four columns are also given, which show the standing of the compound on the basis of best performance under the several headings; this comparison is, obviously, a rough one only. The names of enginemen are given, as it will be seen the men are unequal in capabilities, for the purpose of drawing attention to the fact that the compound (No. 827) was run by two different crews, one of which was probably the best and the other the worst on the list. The influence of these different men on performance of the compound is partially shown in Table No. 12. Here the average saving in coal for the entire eleven months for the compound is seen to be 10.7%; for the five months when it was run by Rusch, he saved 17.5% over the average of the other engines for the same period; for the six months, when compound was run by Fidlin, he saved but 4.3% over average of the others. In the last four lines of No. 12, it will be seen that Rusch is apparently a better man than the average of the others by 2.1%, while Fidlin is worse by 5%. Of course, too much reliance cannot be put upon such a comparison, but it would seem that something must be added to the results shown by the compound with "both engineers" to place it upon the plane of an *average* performance. It may be further noted that Fidlin took the com-

pound in the latter half of the period, when it was nearly ready to be "shopped." Up to the date of this report, five of the engines had been shopped, and in order to obtain some idea of the comparative cost of the compound for repairs at a period when all required general overhauling to put them into first-class condition again, Table No. 13 has been compiled. The results shown will be referred to further on.

REMARKS UPON INFORMATION COLLECTED.

It will be seen that the foregoing information, collected from various sections of the country, tend to indicate *on their face* almost unanimously, a varying but large economy of fuel for the compound when compared with simple engines. Your Committee feel obliged to state that they are not willing to accept all these results at their face value in contributing to a final solution of the question of fuel economy. Presumably the tests were submitted as being more or less comparable, and yet in some cases they are obviously only remotely so, and not one word of explanation accompanied them. Your Committee, therefore, respectfully submit the figures to the wisdom of the association, with few individual comments.

Referring to last year's report, in the final paragraph the prediction was ventured that with friable Western coals an average economy for compounds in freight service should approximate 17%, this figure being the maximum obtainable upon the average, with engines worked in the best manner, in perfect physical condition, and in what may be called characteristic freight service of the country. It is interesting to examine the further figures here given for the same engines used for basis of last year's report, and which have an additional year's service. (See report from C. M. & St. P. Railway and Tables 1 to 13.) The first fact to be drawn from the figures is that, while the averages of nine simple engines probably give a very just and close approximation to the operating cost of that class of engines for the given conditions, a comparison of same with only *one* compound can hardly be called conclusive; and yet the results are valuable, taken together with the committee tests of last year, and tend to confirm the latter, particularly as an attempt was made to eliminate the effect of "individual running" by changing enginemen.

The only advantage, if this can be called an advantage, which the compound enjoyed, was that it carried 20 pounds higher pressure than the simples. It is but fair, however, to repeat here that the higher pressure was needed for the compound to put it upon an equality with the simples in hauling power, the former having been under-cylindered. In last year's tests the Committee raised the pressure on the simple to 200 pounds (same as the compound), but failed to identify the resulting coal economy, and were obliged to reduce the pressure again on account of underbalance of the valves.

It will be seen from these figures that the increased coal economy obtained with a compound engine of the Vauclain system, under the given, and average, freight conditions in last year's tests (17%), is somewhat reduced in more prolonged service by a figure depending on the amount of work expended upon the compound to keep its valves in fair condition, but that the average economy hardly falls below 12%, allowing cost of repairs to still be kept within a practicable figure. It will be noticed that your Committee do not say "within the average figure," as they are not prepared to say the *practicable* will be the *average*; the word is rather taken to mean an amount consistent with the ordinary regularity of performance of the engine, an important consideration.

The above is limited to apply to the Vauclain system of compounding, as the piston valves there used are, in the opinion of your Committee, certain to require more careful watching than the common form of slide valve.

As to standing of the compound in respect to other operating expenses, some information may be extracted from the tables. It would appear that the amount of valve oil required for the Vauclain engine is considerably in excess of that for the simples—according to Table 13 about 20% more, the machine oil needed being about the same. The above seems a reasonable conclusion for this type of engine. Of course, the valve oil question is not of very vital importance if the fuel economy stands at the figures referred to above, but the question of repairs may easily turn the scale in either direction in net results. In Table 13, the repairs per mile are given for five engines for the first 55,000 miles of their life, and including in each a general shop overhauling. According to these figures, the compound stands just with the

average. Members of the association are at liberty to draw their own conclusions therefrom; your Committee believe them not unfavorable to the compound, as far as they go. They partially dispose of the fear that a compound would prove an unserviceable machine from frequent and untimely breakdowns. As the repairs above given include only the customary ones in the first period of an engine's life, such as turning tires, renewing packings, one or more new crank-pins, driving-box brasses and general lining up and overhauling; they do not dispose of the question of wearing out of additional parts and surfaces of the compound, nor to offset this the increased economy of compound in boiler repairs, as is claimed by many to exist.

CONCLUSION.

The association may possibly expect a definite expression of opinion from the Committee respecting the value of compounding locomotives, seeing that they have been at work upon the subject for two years. Your Committee feel, after looking at the question according to their ability, that they can venture an opinion, but that it is only an opinion, and does not finally dispose of any one point broadly. In looking backward at the beginning of the agitation of the subject in this country, the arguments for and against compounding in locomotive practice form instructive reading. The possibility of fuel economy was first denied because it was argued, we have only marine and stationary practice to turn to, and there the work done is fairly constant and is consequently well adapted to compounding, in which the cylinder ratio is an all-important factor. This reasoning is not sound, and the fallacy of its conclusions has been conclusively shown in the past two years; for one example, see conclusions of this Committee last year, where they presented tables showing an even wider range of economical performance for the compound than for the simple. Of course, both types fall off seriously in economy under variable conditions, but the compound less so than the simple.

Another argument advanced against the compound is that new machines always give economical results while watched. This is emphatically true and constitutes the most serious stumbling-block to the conscientious investigator. It is however no more applicable to compound engines than to any other machinery, and

the economical results obtained from simples in long service should lead us to hope for the same of compounds, at least at this stage of the question, when it has been shown that they will run 50,000 miles and over without serious impairment of efficiency.

Turning again to fuel economy, your Committee believe the greater number of thinking and observing men in the profession to-day believe the compound will save coal under certain conditions; some of these men deny that these conditions can be fulfilled in practical railroad service. Others say that the fuel economy will be wiped out by increased cost of other supplies and repairs. One condition referred to above is that the compound is not as powerful a machine as a like simple, and must be provided with a starting-valve to allow it to work simple in starting and on hills; this valve, it is claimed, will wipe out the economy, because it will be habitually used, not so much from carelessness of enginemen as from the fact that the operating department will find out they have a more powerful machine at their disposal when the occasion requires, and will load the train until the habitual use of the valve becomes a necessity. From one point of view it may be with justice said that no one would expect economy under such conditions; but it can be with equal justice affirmed that master mechanics will have to meet this condition. It, therefore, behooves designers to strive for equal power for the compound without the use of such a valve.

As to the other question, of repairs, your Committee have brought results as nearly up to date as practicable, and are not disposed to go far behind the figures in offering a definite conclusion. The compound is a new machine, it is subject to certain crudities of all new designs; these will constitute defects which will cost more for maintenance than the perfected points of the older type. But no evidence has been advanced to show that these defects cannot be remedied by time, and this part of the question resolves itself to consideration of extra cost of maintenance of additional parts in the compound. As the fuel saving possible is not an excessive amount, it points to the conclusion that we must strive for the greatest simplicity and greatest reduction of number of such parts in the new type, if we are to expect a net saving in service.

While upon this point, your Committee wish to call attention

to the unwise policy of locomotive builders in so many cases advocating compounds of entirely different type and dimensions from the simples formerly used, thus making comparison difficult and producing an experimental type which is possibly not well suited to the work. All are surely interested in quickly disposing of the question of availability of the new principle—a solution retarded by a multiplicity of designs.

Your Committee feel they have already trespassed too far upon the attention of the association without adequate return. They have, however, as yet said nothing of the use of compounds in passenger service. The results of tests for this service are both meagre and inconclusive. The conditions are such that the compounds have less chance for profitable employment here than in freight; the difficulties of design, at least, are greatly increased; as, for example, in the valve motion, where the high piston speeds and short cut-offs in high-pressure cylinder produce unmanageable back pressure.

Your Committee, therefore, offer tentatively the following opinions and suggestions:

1st. The compound is suitable for a variable class of freight service.

2d. Its range of economy in such service is fully as wide as that of the simple.

3d. Its increased coal economy over the simple in the average freight service of the country will be found to lie between 10 and 15%, when in good running condition and handled with intelligence.

4th. A well designed compound should not be more difficult to keep in a serviceable condition than a simple; that is, its regularity of performance should not be less than with the simple.

5th. The four-cylinder compound will cost more for valve oil than a simple.

6th. The running repairs of a four-cylinder compound will be somewhat more than for simple; for a two-cylinder compound, they should not be more; the final comparison for repairs is undetermined.

7th. The net running cost of a compound will be less on many roads than of simple, the figure depending upon the design, cost of fuel and other local conditions.

8th. In passenger service the availability of the compound is undetermined.

9th. Complicated designs of compounds are not likely to prove successful or economical. The prevailing forms of starting valves, in use in this country, are especially noted as being too complicated—certain valves employed abroad seem to have more commendable points.

10th. Attention is called to the necessity of long time tests and averages of a considerable number of exactly similar engines of both types to properly establish the status of the question. In such tests the influence of higher pressure for either type should not be allowed to complicate the results, as the effect of the highest modern steam pressures on economy of the simple is undetermined.

GEORGE GIBBS,
WILLIAM H. LEWIS,
PULASKI LEEDS,
JAMES MEEHAN,
T. W. GENTRY,
Committee.

On motion the report was received.

DISCUSSION ON COMPOUND LOCOMOTIVES.

The PRESIDENT—Gentlemen, the question of Compound Locomotives is before you for discussion. I sincerely hope that you will take hold of it and discuss its merits with those of the simple engine in a most earnest and scrutinizing way. Let me ask your earnest attention to this subject to-day.

Mr. S. M. VAUCLAIN—In glancing over the report returned by the Committee on Compound Locomotives, I notice that the majority of the engines taken into consideration have been Baldwin compounds. It is therefore proper that I should make some remarks in regard to the conclusions or opinions offered by this committee. Preliminary to those remarks, I might say that up to the present time we have some 460 compounds, all told, on order, and we have slightly more than the number here given in service.

The first opinion that the committee offers is that the compound is suitable for a variable class of freight service. I take exception to that opinion in this way: We consider that the compound is suitable for all classes of freight service. We have compound locomotives working in freight service that weigh from the lightest ordinary American type of engine up to the very highest decapods, weighing 200,000 pounds. We have reports from the railroad companies using those locomotives that the light engines give satisfaction in the service that they are employed in, and that the decapods give satisfaction in the service that they are employed in.

Therefore it is very proper to suppose that compound locomotives not only give satisfaction, are not only suitable for a variable class of freight service, but for all classes of freight service.

The second opinion of the committee is that "its range of economy in such service is fully as wide as that of the simple." It would seem to me that that would read better if it said that its range of performance or of coal consumption per ton-mile is fully as wide as that of the simple engine. We have found in all cases where compound engines have been compared with simple engines of the same size in the same service, no matter what that service has been, that the economy has been affected—the economy has varied and increased, as the demand was made upon the engine. In other words, the harder you work the plain engine and the compound alongside of each other, the higher the rate of economy would be for the compound engine.

The third opinion of the committee is: "Its increased coal economy over the simple in the average freight service of the country will be found to lie between 10 and 15 per cent. when in good running condition and handled with intelligence." I wish to state here that I think that 10 and 15 per cent. is the minimum fuel economy that any compound engine of any type, two-cylinder, three-cylinder, or four-cylinder, could probably effect in freight service; that is, in average freight service. I had occasion a short time ago to inquire into the condition and the performance of two compound engines. They had apparently been turned down. They were no good. They wanted no more of them. Upon asking for the figures for these two compound engines to substantiate the statement, it was found that no figures were there, and the master mechanic was told to give the figures. He was a new master mechanic and knew nothing about the engines, and very gladly had the chief clerk hunt the figures up. To my surprise the figures showed that for an eighteen-months' performance of those engines the fuel economy per year on those engines had amounted to $1,680 each; that the mileage for the last month of eighteen months service was the maximum mileage that those engines had performed while on the road; that the total cost of repairs for those engines for the eighteen months had been some 39 per cent. less than the average of all the engines on that division. We think that the average fuel economy in freight service should not fall below 20 and 25 per cent. We have known it to run far beyond that. We have reports from some railroads that show very much larger economy than that, and it is reasonable to suppose that that economy was obtained or it would not be reported. On heavy grades, with heavy engines, we find that the economy has reached as high a figure as 44 9 per cent. This was done on the Western Maryland Railroad.

The fifth point of the committee is: "A well-designed compound should not be more difficult to keep in a serviceable condition than a simple; that is, its regularity of performance should not be less than the simple." This has also been found to be so—and more than so. It has been found by a number of railroads, especially where bad water has to be con-

tended with, that the compound requires less attention than the simple engine. It does not require to be washed out so often. The mileage is greater for that reason. We have reports from some railroads, and the master mechanics of those roads, I think, are present and will bear me out in the statement, that compound engines delivered at the same time as the simple engines are still running with the flues in them, whereas the plain engines have had the flues removed. These figures show that the regularity of performance would be just as good as that of the simple engine, if not better.

The committee say, in the next place: "The four-cylinder compounds will cost more for valve oil than the simple." We find a number of instances in this report where railroads are using less oil on a four-cylinder compound than on a simple engine. I think it is not necessary to call attention to the use of valve oil, that a four-cylinder engine should have more valve oil than a two-cylinder engine; and as it is a very small item in the expense of operating the locomotive, it is not worth while to consider it. We think that those who use less valve oil on the compound engine than on the simple engine, should either use less on the simple or more on the compound.

The sixth opinion of the committee is that "the running repairs of a four-cylinder compound will be somewhat more than for a simple; for a two-cylinder compound, they should not be more; the final comparison for repairs is undetermined." The only additional repairs that can be given to a compound locomotive over and above a simple locomotive would be the repairs due to the cylinders. The representative of a railroad of this country is present to-day—a road that has undertaken to eliminate from the total repairs to their locomotives the cylinder repairs, and it was surprising to find the small percentage of the total repairs that the cylinder repairs amount to. I am willing to concede, although it is not exactly true, that a four-cylinder compound should have twice repairs to its cylinders and cylinder parts as a two-cylinder engine, so far as the cylinders are concerned; intercepting-valve and so forth, of course, are not included. This percentage of repairs is so slight that you can afford to cancel it entirely. The large item of repairs is the boiler repairs, and it has been clearly proved that the boiler repairs to compound locomotives are very much less than what they are to single expansion engines, due, of course, to the amount of work demanded of the same sized boiler in a given time.

The seventh point is: "The net running cost of a compound will be less on many roads than of simple, the figure depending upon the design, cost of fuel and other local conditions."

It seems to me that it costs just as much to provide a crew for a compound engine as for a plain engine. It costs just as much to keep up your running parts, a little more to keep up your cylinders on a compound than on a plain engine. You have the advantage of the decreased repairs to your boilers which more than offsets the increased repairs to the cylinders,

and you have your fuel economy as a clear gain. So there cannot be any question but that there is an economy in operating compound locomotives.

The tenth point is : " In passenger service the availability of the compound is undetermined."

Gentlemen, I object to this. I think this has been determined. If the committee would take the trouble to come to the East, where we are running high-speed passenger trains—dozens of them daily, they could find the compound engines are hauling a great many of those trains and hauling them well. On the Philadelphia & Reading, high-speed trains are hauled by them. High-speed passenger trains between Philadelphia and New York are hauled by them ; also on the Central Railroad of New Jersey. I had occasion the other day to show an English gentleman, a friend of mine, over the road. He was surprised at the speed that the compound engines were able to maintain and the smoothness with which they worked. The Washington limited arrived at Philadelphia at 12:57 on the Baltimore & Ohio, and went from there to New York by the Reading and Jersey Central. It was taken as a sample train, hauled by a compound with Wootten firebox. The train was twenty minutes late. It had been hauled over the Baltimore & Ohio by a single expansion engine. The train was very heavy, having six vestibuled cars. We took the train at Twenty-fourth and Chestnut streets, and before we got to Elizabeth we had fourteen minutes of the schedule time made up. We went in slightly ahead of time in New York ; had to stop on the draw. We ran 55 miles in 53 minutes over grades of 34 feet to the mile ; slowed up for water and slowed up for the Lehigh Valley crossing. That I think is not very slow running, and it has proved that compound engines are just as well adapted to high-speed passenger trains as to slow-speed freight trains. On the Philadelphia & Atlantic City Railroad, with their fast trains the economy of coal is about a ton and a half for the 56-mile run each way, which shows that they not only haul the trains with perfect satisfaction, making up from 10 to 15 minutes on a 70-minute schedule, but doing it at a very much less rate of coal consumption.

The eleventh opinion of the committee is as follows : " Complicated designs of compound are not likely to prove successful or economical. The prevailing forms of starting-valves in use in this country are especially noted as being too complicated ; certain valves employed abroad seem to have more commendable points."

From this it would seem that we are not to encourage the builders of two-cylinder compounds in this country who necessarily must use starting-valves. It intimates that the starting-valves abroad are very much more desirable than the starting-valves that we have at home. I have been doing something in the way of two-cylinder compounds this last year or two. We certainly do not like a complicated starting-valve. There must be some complication to the valve. There must be some valve there. What I might call complication, some one else might not. It is true that some of the starting-valves put on in this country have been abandoned by the rail-

road companies using those engines, and valves or operating mechanism of their own design, substantially, have been substituted in place thereof. But in conversation with Mr. Clement E. Stretton, I was informed that the London & Northeastern were abandoning the use of two-cylinder compounds, and their future passenger engines were to be plain engines. I do not see any particular necessity of turning down the two-cylinder compounds and going to plain engines. It may be that the starting-valve does not suit them, and for that reason the engine is turned down. I think that this would indicate that the starting-valves as used abroad are not any more desirable than the starting-valves for the two-cylinder compounds used at home. I am of opinion that the starting-valves brought out in America are very much better than the starting-valves used abroad. I think that the makers of starting-valves in this country should be encouraged, so that the American railroad people can have the advantage of American ideas.

The twelfth suggestion of the committee is as follows: "Attention is called to the necessity of long time tests, and averages of a considerable number of exactly similar engines of both types, to properly establish the status of the question. In such tests the influence of higher pressure for either type should not be allowed to complicate the results, as the effect of the highest modern steam pressures on economy of the simple is undetermined."

I believe that Mr. Soule remarked at the last Convention that a slightly higher pressure was a legitimate advantage due to the compound engine. It was proved conclusively on the Chicago, Milwaukee & St. Paul that an increase of 20-pounds pressure on the plain engines made no difference and that difficulty was found in keeping the valve surfaces lubricated. With a piston-valve, no such trouble was experienced. Consequently, the increased pressure for which the four-cylinder engine was designed was a legitimate advantage. It seems to me that it should not require so very long to determine whether it was any advantage. If a plain engine is put in competition, brand new, with a compound locomotive, one month's service should determine whether there is any fuel economy to be found in the use of this engine. By simply taking the cost of the fuel in dollars and cents, a man could determine whether he could afford to give that engine general repairs every six months, or if it were necessary. I do not think it would be necessary to give a compound engine general repairs every six months. But on several railroads that have reported fuel economy to the Baldwin Locomotive Works, it has been found that those people could afford to set that engine to one side and get a brand new engine in five years on the fuel that that engine has saved. We have one case, so far, where one of our customers returned their single expansion engines to us and had us make them compound. We are certainly making large numbers of compound cylinders to be shipped to railroads to put on engines that they are building themselves, which shows that the compound business is taking hold in the right way, not only in this country, but abroad.

Compound engines have now got a foothold in Japan, and the American engine is in demand. Heretofore the English people enjoyed that trade. We have large orders on hand from Japan, and there is no doubt that it will continue as long as the American engine gives satisfaction. On the Pike's Peak rack-road, which has a grade of 25 per cent., we made three plain engines for that service. They needed an additional engine. We persuaded them to have a compound under the guarantee we offered that it would do the work more satisfactorily than the present engines. The engine was built, and the three plain engines were sent back to our works to be changed into compound engines, and they are now in service on the Pike's Peak road. What it has done is best shown by this letter: "From the little experience we have had with this engine, we think she is going to do the same work as our 28-ton engines on about two-thirds of the coal, and make the run from Manitou to Pike's Peak in from thirty-three to thirty-five minutes quicker time."

Mr. GENTRY—I have just received a letter from our Mr. C. F. Thomas, of the Midland Division of our system, that should have gotten in here in time to come up with these papers. It is the results of some practical tests with one of Mr. Vauclain's engines, along with three others.

The PRESIDENT—Gentlemen, the secretary will read this paper over, and while he is doing that we will go on with the discussion.

Mr. D. L. BARNES—I would ask if any one has ever seen a set of indicator cards from a compound locomotive at sixty miles an hour that was a credit to the engine? The indicator cards give evidence of a loss of efficiency at sixty miles an hour when compared with cards taken from any other engine I have ever seen. This is in contradiction of Mr. Vauclain's statement.

Mr. PULASKI LEEDS—I have very little to say on this matter, for the reason that if we got more information we would have put it in the report In fact, in gathering the information I have been very strongly reminded of a trip I took on one of our heavy roads with rather an eccentric engineer. We came on to the hind end of a train. He immediately put her to back motion, and turned around, and patting the boiler head, he said: "Save my job, old gal!" I have got different reports in going around quietly, from engineers and firemen, from what I have got other ways. At the same time I have no attack to make on the compound in any way, shape or manner. The only thing I would call attention to is that our reports are read by the management of railroads, and I rather protest against some assertions going in that are misleading, unless someone takes exception to them. I protest against its going in that the compound is 39 per cent. more economical in repairs than the average of the engines on any railroad. I do not see any reason why it should be so, except this: the average of our engines on all our roads—take my own system—ten or twelve engines a year are condemned, destroyed, and that goes in as running repairs, distributed over all the rest, of course, and incidentally with the new engines. Next comes a class of engines which it takes very good

judgment to say whether it is worth while to put on them the extensive repairs necessary to maintain them—whether it would not be a good idea to condemn twenty-five or thirty instead of eight or ten. That all goes in, and still we are asked to compare that with a brand new engine.

On the other hand, I take exception to the statement that there are no repairs due to the compound engine except repairs to the cylinder. At any time that I can get rid of a pound in my reciprocating parts I try to do it, for the very reason that it carries extra weight in the engine all the way through, and not only that—a weight that is effective only a part of the time and during the rest of the time is more or less destructive; although I am not exactly an advocate of the hammer blow.

Mr. MITCHELL—I see by this report, that on the New York, Lake Erie & Western, we show a large saving in lubricating oil over the simple. I wish to state in explanation of that, that we had forty-five engines built, one of which was a compound. On the compound we had one man. We took the consumption of oil of this one engine, with the regular man, against the average for the forty-four, which showed this saving. So this is not a correct comparison between two individual engines.

Secretary SINCLAIR—The usual course with communications similar to this one received from Mr. Thomas, is to hand them to the chairman of the committee on the subject. The association has always objected to receiving communications on a subject for which there has been a committee appointed. This relates very directly to the question and certainly ought to have been sent to the chairman of the committee, but there is information in it that the Executive Committee think the meeting ought to have. It is as follows:

ALEXANDRIA, VA., June 18, 1893.

Mr. T. W. GENTRY, Master Mechanic, Manchester, Va.:

DEAR SIR—In regard to the ten-wheel passenger engines, 820, 821 and 823—the latter Baldwin patent compound, which have been recently put in service on the V. M. division on trains 37 and 38, "The Southwestern Vestibule Limited," 232-mile run. The running time of No. 37 shows 6 hours and 24 minutes, or 40.3 miles per hour. No. 38 shows 6 hours and 6 minutes, or 43.9 miles per hour, which includes the following stops: six stops for water at one taking coal, and cleaning fire at another taking coal, besides taking siding as they pass on this division with a train of six cars, two postals, combined dining and baggage, and sleepers, all vestibule except first postal.

These engines are ten-wheel type 20 x 24-inch cylinders, 66-inch wheels, and radial stay-boilers, exactly the same except changes made for compounding engine 823; increasing her total weight to about 134,000 pounds, mostly on engine-truck. Simple engines have 175 pounds steam pressure. Compound has 180 pounds pressure. When engine 823 was put on the run, it was found we could not get the time out of it; and it was taken off the run. The Baldwin Locomotive Works then sent other valves, which were placed and set, making some other changes in travel. Before changes were made, the engine showed about thirty tons of coal saved over simple engines in about 5,500 miles service, but was not making time on schedule, lost on hill running. The changes made in valves (which you will note) have brought the consumption of coal up to practically the same as sim-

ple engines, as far as we are able to judge from the short time it has been handling these trains; although the table of time taken on inclosed sheet on some of the hills shows the simple engine having the advantage. The time, grade and curvature, is not as heavy as some other parts of the division, yet it is the best part of the road to get comparable results without interference from train running, as to stops, meeting points, etc. As to repairs, I am as yet unable to speak.

The coal includes all coal used on these engines. Fires are banked 18 hours at Danville and 9 hours at Washington, each round trip; or in other words, fires are only drawn after 50 hours' service.

C. F THOMAS,
Master Mechanic.

The PRESIDENT—This communication will enter the proceedings as a part of the discussion. Now, gentlemen, we want all who have information on the compound locomotives to speak out. No one should leave this room who possesses any information in relation to this subject without presenting it to this meeting.

Mr. HENDERSON—Mr. Vauclain spoke of the cylinder repairs and of a record that had been kept by a railroad. That railroad was the Norfolk & Western. We kept a record for the first four months of this year of the proportion which cylinder repairs bore to the total repairs on simple engines. We have thirty-two to thirty-four compound engines running, but those were not included in this list. A form was got up for the purpose and sent to all the subdivision shops, upon which they entered the amount of work and material applied to cylinder repairs, so that they could be compared with the total. By cylinder repairs was meant that work which was done on pistons, piston-rods, piston-rod packing, valve-stems, valves and steam-chest. It did not make any reference to the guides or steam pipes, but merely what was directly reducible to cylinder repairs. We found out from this record of four months that the cylinder repairs were about 2¾ per cent. of the total repairs for locomotives. Now, if we look at that in the light of the information which our last annual report shows, we can get some idea as to how that would tend to reduce the value in saving the coal. Our annual report for 1892 showed that for 100 miles run fuel cost $3.86, and for 100 miles run repairs cost $6.36. Now, if we assume the cylinder repairs to be 2¾ per cent., as our data show, of the total amount of repairs, we have 2¾ per cent. of $6.36, equal to 17½ cents for 100 miles run due to cylinder repairs only. Our coal is fairly cheap. It costs us 78 cents a ton. We run right through the Pocahontas region. Now, Mr. Vauclain said that he thought that the lowest economy allowable for compound engines was 10 to 15 per cent. The report also of the committee stated that the economy might be considered from 10 to 15 per cent. If we assume it at 10 per cent. and find that our fuel for 100 miles run averaged $3.86, we find the saving to be 38 cents for 100 miles run. If we assume the cylinder repairs of the compound to be double that of the simple, which Mr. Vauclain states he thinks is ample, we have a deduction to make from the coal saving of 17½ cents per 100 miles. By deducting that from the 38 cents saved in the coal, we will have a saving of 20½ cents per 100 miles, or,

Mr. David Brown—When the committee wrote to me for information with regard to the compound, I said that I did not have any up to that date. But since then the road on which I am employed has got one. It came about in this way. We have pretty heavy milk trains running, and the milk trains make a rather heavy load for the engine. That is, it was too heavy for the traffic department. We thought the engine ought to pull the trains, but we found that the engine would not pull the number of cars they wanted to put on at that time. Consequently, I began talking the matter up to see if I could not get a couple of engines made to do the work. They wanted them at that time to pull eight cars. They could pull seven, on the hill, but not eight. I had permission to build a couple of engines. We got talking the matter over, and it was finally decided that we would build one of them compound. The idea was that we would build them ourselves. But I said that we would have to have some castings, etc., and it would not pay us to make patterns, and I was told to buy what we could get. The Baldwin Locomotive Works very kindly offered to sell us anything we needed, but they put in—Why not let us build it? I thought it would probably be better for them to build it, and the thing culminated in an order being given to them. It was an engine something similar to the engine on the New Jersey Central.

As soon as that order was given we started to work on another engine. On the 13th of January we received the Baldwin and on the 26th of January our engine was out of the shop, and the two engines being something of the same size it naturally caused a little bit of excitement among the men, and the superintendent put them on some trials to show one against the other, and the first trial that they were put to the cars were increased to twelve with a heavy caboose of 34,000 pounds. They had a helper on the engine. The hill is about seven miles long. The superintendent told the puller to go ahead and let the compound take them alone, and she did take them alone and went up in thirty-six minutes. The schedule time was twenty minutes. The next day the superintendent thought he would try the regular engine that had been on that train. She was a mogul engine 19 x 24. The puller was told to go ahead. She did go ahead, and when a mile out of the city she stalled. The thing went along, and two days after, the simple engine, that we had built, was put on the train. This was a 20 x 20, with boilers the same size as the Baldwin—64-inch. We had more flues—288 flues, and the fireboxes are a little wider. She was put on the train, and took the train up in twenty-eight minutes. That was eight minutes less than the compound.

The next thing, when she returned, they cut the simple engine out at Stroudsburg, and laid her over two or three hours to bring the vestibule train up and see what she would do with that. I will state that, at that time, the regular passenger engine would lose anywhere from four to six minutes in the forty-five minute run up hill, and at the best she would never make the time within a minute. The train of five vestibule cars was a little too much for her to make her regular time in, and they put the

simple engine on, and she got up in forty-two minutes and a half. They thought then she was a pretty good engine. The compound went in one day and the simple engine the other. They both ran the same trains. We had a little trouble with the compound at the time. The piston-glands gave out. I suppose the piston-glands were supplied by Jerome & Co. The engineer of the Baldwin Locomotive Works was there, and he requested us to make new piston-glands, which we did. She was cut out one day and put in this fast line. She made the hill in forty-seven minutes and a half. That was five minutes more time than the simple engine.

All this time we were talking about fuel. We had no means of weighing our fuel there, because they will take coal at Scranton, or Binghamton, or Washington, wherever they want it. They simply take it out of the chute and go ahead. The firemen on these two engines had formerly been on the mogul, and they both were very well pleased with the amount of fuel that was used. They said, as near as they could tell, that they were using less fuel than with the other engines. I insisted that the compound would run with less fuel than the other. The engineer and fireman told me so. I changed the firemen around, and they were of the opinion that the simple engine burnt less fuel.

After a while it was decided that we would weigh the fuel. We let one engine run north one day and the other south. They did that for four days, and then they started out on four days more and changed around so that they made the same number of miles in the four round trips, and the results were not what I expected. Instead of the compound using less fuel, the simple engine did. I will say, though, that the simple engine's nozzles were 3½ inches. The compound nozzles when she came there were 3¾; but she would not steam with the anthracite coal until they were shut up to 3⅛. Of course, the more they closed the nozzle the less satisfactory results would be shown on the engine. Anyhow, they had to close them to get the steam. The anthracite fuel, I suppose, is as good a run of coal as there is in the lower part of the country, where the compounds are at work at present. However, the result was this, that in the four days' run the simple engine had saved 18,300 pounds. The simple engine made about 50.9 pounds, whereas the other was 66 and a decimal.

While the trials were going on I was advising both crews to do the best they could, which I believe they did. If they can do any better, why, we will let them try again. But I believe both crews did as well as they possibly could under the circumstances. Now, as regards the repairs, we have not had any trouble whatever with the compound cylinders or valves. The heads were taken off one when she came first. The machinist had left a half-inch round file in one of the valves, and she had run from Philadelphia and did not do any damage except breaking up the file. We got the file out, and that is the last time the head has been off.

The engine is working very well. On one of the cylinders the bolts shook loose last week. We had to put new bolts in that, and we have had one of the by-pass valves give out owing to a defect in casting. That is,

there was a piece of coal shut in it. Trainmen do not like the riding of the engine down hill. I think if the compound engine would ride better down hill that they would like it better. If there is any means of making her ride easier she would be more of a favorite. But as it is, the men really do not like going down on her. The head brakeman who is supposed to ride on the engine won't ride on her, but goes back on the train going down the mountain.

Aside from that, the engine is doing very well. There is very little difference in the engine excepting those points. The simple engine seems to do it a little bit better. Probably it may be said that we may think so because we built the one and bought the other. But I guess the gentlemen in this room can know the working of the engine just as as well as I can, because it is there to be seen, and they can hear the same parties talk about it that I heard.

Mr. BARNES—Before the speaker sits down, Mr. President, will you ask him for the dimensions? We would like to know the diameter of cylinders on the two engines, the steam pressure, whether the engine was running with the throttle wide open or not on these tests, and something like the speed up the hill.

Mr. BROWN—Well, if they are on time they have got to average thirty-five miles an hour. If they are not on time, they may run fifty miles an hour to get there. The engineer on the simple engine, which, as I said before, has a 20-inch cylinder by 24 stroke, said, when I asked him how low down he worked, that he never went below 12 inches. They are now running fourteen cars and the caboose. They have help up the hill. The compound has 14 and 24 and 180 pounds pressure, and the simple engine has 160 pounds pressure. The heating surface of the simple engine is 2,082 feet. She ought to make good steam, and she does.

Mr. W. F. BRADLEY—I think we make too many comparisons that are not comparisons at all. I think when you want to make a comparison with a compound engine, unless you have something to compare it with, it is a waste of time to talk about a comparison. When they talk about 50 per cent. comparisons, there must be something loose. We have six compound engines and two engines of the same pattern built for the same size, and I think of this thing about operating them with the starting-valve, and so forth, that if you took that starting-valve and yoked it, and ran the other engine as you pleased, you would not find 50 per cent. more consumption in fuel. As this gentleman spoke over here of comparing the Baldwin engine of a passenger train with another Baldwin engine, he says when he returned he found they were using 50 per cent. more fuel. Well, if the engines were of such sizes and dimensions that they would stand comparisons at all, I do not see how they could operate a compound engine to burn 50 per cent. more fuel. Of course, if the engines were such that there was no comparison, why then there is no use in talking about any comparison.

Secretary SINCLAIR—Does Mr. Bradley entirely understand that he has given a flat contradiction to a gentleman who has given figures?

Mr. BRADLEY—I do not want to give a flat contradiction. But my experience is such that I do not see how it could possibly come about. I do not contradict the gentleman's statement, but I say my experience is contradictory to his experience. Take our engines. The poorest result we have had with one of the six engines in the same service could not possibly show more than 10 per cent.—probably the very worst results of the six engines as compared with the single expansion engine built to the same size. I do not think that the worst results of any given period of six compound engines as compared with two others would show a difference in the consumption of fuel of anything like 50 per cent.

Mr. LEEDS—I would like to ask if the gentleman who made this statement in the first place did not give us very fair comparisons? As near as I could understand it, it was the same engine. The first engine worked, in the first place, high pressure all the while—live steam and not compounding.

I have found a gentleman that made very nearly that same statement. In other words, he made the statement that the engineers had found that they had a very powerful engine on the hill, and that he had to renew his tire about twice as often as he did on the simple engine of the same power when the compound was working as a compound, and also that he had found that he improved the performance to a great extent since he had impressed it on his men that they must not work the compound engine except as a compound, unless it was in an emergency. I would like to hear from Mr. Mackenzie on this point.

Mr. JOHN MACKENZIE—I did not propose to say anything on the point, for the simple reason that we know but very little about it. Some ten months ago we had ten engines built by the Baldwin Locomotive Works, and in placing the order the president said: "I suppose you want a plaything, the same as everybody else, and if you want a compound you had better get it."

I told him I did not have very much time to monkey with compounds, but I would be glad to experiment for his benefit, anyway. So we got the compound engines. Those engines were put into use. Our method of handling is to assign regular men to regular engines, allowing those men to make thirty days during the month, and whatever time the engines may make beyond that is made by extra men, holding in all cases the regular man responsible for the condition of the engine. We made no test as to weighing the coal or the water, or measuring out the oil or waste, or any other work about the engine. But the engines were simply put into regular service, and in the eight months the engines have made nearly 32,000 miles, or an average of about 4,000 miles a month. The comparative statement would be about as follows: The cost per mile run for an average of nine simple engines for repairs, was seven mills; for the compound, one cent and two mills. The stores were just the same. The fuel on the simple engine was ten cents and three mills, and on the compound eight cents and four mills, the total cost of the two engines being 1,808 and 1,604, or a saving in the cost per mile run of the compound over the simple engine of 18.44.

The cars per train in the simple engine were 30.1, average train, as against 31.7, or an increase of 1.2 cars per train. The number of miles run per ton of coal was with the simple engine 16.2, and with the compound 20.2, or a saving of 23.42. The cost per train mile was six mills simple, and five mills compound, a saving of one mill in the compound. The pounds of coal per ton-mile were 4.1 simple and 3.1 compound, or a saving of one pound of coal per train-mile. The engines are identical in every respect excepting the cylinders. We use our own specifications throughout. With the cost of coal at 8½ cents per 100 miles, our coal costs $1.77 per ton, and shows a saving in favor of the compound of 31.7 per cent per train-mile The cost of repairs of the compound over the simple engine is five mills per mile. In speaking of the cost of repairs, I would say that I am not positive as to whether there were any incidental repairs made upon the cylinders or not, because that was not drawn to my attention, but we have a record of extended repairs being made to the crossheads. Twice during these eight months we have had to take the crossheads down and reline them. Our master mechanic, Mr. Miller, is here and I will ask him to answer some questions afterwards.

As to whether the cylinder-heads have been taken off—they have not been taken off for anything else than simply to look at them, to know that the pistons were in there. We think we use a very good packing. We have a peculiar idea of getting them up, and we run them a long time without looking at them. I would say that the repairs to the cylinders we know nothing about. I think there have been no repairs to the cylinders. The crossheads account for all the repairs on the compounding system. I want to say that the repairs to the eccentrics and links and rocker-arms are going to be very much less than on the simple engine. Our simple engines are running 300,000 miles without facing the valves of the engine. Now, the experience we have had so far with the light wear of the eccentrics is, that the work of the engine is going to be very much less than on the simple engine.

As to the repairs upon the flues—I do not believe there is very much to be said about flues, for the simple reason that we had a very bad job come out of the Baldwin Works, and Mr. Vauclain, I think, knows of it. We had a very bad job of flue work on all the engines, and we could make no comparison until the flues were removed, which we have had to do. Now, as to what the benefits will be from the compound in respect to the boiler, we are unable to say.

As to the washing out, we have noticed no difference that I know of. We wash them regularly, as often as we wash the simple engine. Of course, there is some advantage in bad weather with the compound. Our engineer says that he can always get there for water while the other boys sometimes have to cut and run. No matter how bad the weather is, he always gets to the tank that he has selected.

Mr. Leeds has brought it out as to the wear of the tires. We found an excessive wear of tires on the compound engine—that is, up to four months

ago—as compared with the simple engine. I questioned very seriously why that was so. I took our traveling engineer to task about it. I said there was only one conclusion to come to, and that was abuse of the engine. The weight would not do it. The engine was heavier, if anything, on the wheels than the other engine, and we concluded that the engineer used his high-pressure steam in his low-pressure cylinder. I think that they found that that was the cause, and that has been stopped.

To illustrate that part, we have one place in the city of Cleveland where we have a grade of about forty-two feet to the mile. It is usual to push a train out of there having over thirty-eight cars. The compound has been going in there with forty cars, and if the pusher was not ready he would take the train and walk out with it, while the simple engine would have to wait there until the pusher came around. (Applause.)

I would like Mr. Miller to state to the Convention as to whether he has made any extensive repairs to the compound engine in the cylinder.

Mr. W. H. Miller—I could only confirm what our superintendent of motive power has said in regard to our experience with the compound. There have been no repairs made of any kind on the cylinders. We have had the heads off simply to satisfy ourselves that everything was right in the cylinders. That includes all the cylinders, the globe-valves and the steam-chest and all. There has been no work of any kind done in renewing the rings or anything in connection with the cylinders since the engines have been in service. We have had some annoyance with the cylinder-cock rigging. The small steam rigs worked out fast, allowing a blow. We have been obliged to renew them. They are all small rings about 2 inches in diameter. With the exception of this little annoyance and small expense there has been nothing in connection with the cylinders.

On the crossheads, as Mr. Mackenzie said, the lining has been renewed twice, causing the expense of tearing down the work to get them out and putting on the metal, planing off and truing up. That has been the largest expense that we have had to contend with on those engines, except that which came from the effect of workmanship when they came out of the shop. The tires show about double the amount of wear as compared with other engines of the same class, because of the incorrect practice of using the engines.

I should state, as a matter of justice to this engine, that we did not put any crack engineers on it. As you know, there are engineers that are as far superior to others as compounds are superior to the common. In this case, we have what we consider an average engineer on this engine—nothing extra—so that there has been no advantage to the compound in the men handling her. (Applause.)

Mr. John Tonge—As has already been stated in referring to the Baldwin engine, the workmanship is very inferior, which has made it very expensive to us to keep in repair. But, setting aside the question of bad workmanship, it is safe to say, so far as our experience goes with the Rhode Island compound, that they have shown a saving of 12½ per cent., with an increase of repairs of 50 per cent.

Mr. HIGGINS—Mr. President, I believe there are some compound locomotives on the road you are connected with. I think the members of the association would like to have your experience.

The PRESIDENT—I wish to say to the members that I am anxious to hear the experience of others before I state what I may have to say about it. I would ask Mr. Wells to enlighten us on this point.

Mr. REUBEN WELLS—I have not had any practical experience with compound locomotives. We have built only two or three, and these have been sent away to other people, who have had the experience with them. These locomotives have been of the two-cylinder type.

There is one question that comes up which I would like to get some information on, and perhaps some other members of the association would also like to get information about it, and that is—If a party is called on to build a compound locomotive equal in capacity to a simple engine, what difference must you make in the area of the cylinder, and how much more steam pressure must you carry to make that compound an equivalent for the simple engine? Now, in the discussion by many of the members and in reports, we find that a compound engine with its high-pressure cylinder, of the same size, the same area as a simple engine, is weak; it will not do the work with the same steam pressure that a simple engine will, and in my investigations I concluded, and my conclusion was in accordance with the experience of most people who had observed it, that there is about from 25 to 30 per cent. difference; so that in making a compound locomotive to do the same work as a simple engine it is necessary to keep this matter in view. If you use high-pressure steam in the low-pressure cylinder you can gain something in that direction. You can gain in an increase of pressure; also, you can gain an increase in the length of the stroke. But the question is—What is the nearest we can come to it? That is, how much larger in area should the high pressure cylinder be than the cylinder of the simple engine? Or, where it is a four-cylinder compound engine, the compound to the two high-pressure cylinders would, of course, be equivalent to a single high-pressure cylinder of a two-cylinder compound.

I have not any doubt but that the compound locomotive when properly built and managed is economical in fuel. I do not think there is any question about that. We probably do not know exactly what the difference is. Probably, as some one has expressed it here. it is somewhere between 10 and 15 per cent. Now, where coal is cheap, as it is on many roads the saving at that rate would not amount to very much in a year, and it may be found that on roads where coal is cheap that there is but little advantage in having compound locomotives, while, where coal costs $2, $3 and $4 a ton, there may be a very great saving per year. Those are things that, of course, will be determined in time. You will find out after a while how cheap coal must be before a compound locomotive ceases to be an advantage over a single expansion.

I was very much interested in this committee's report. I think they made a very good report, and I am not at all inclined to criticise it. I think

their report is very good and correct. It is, at any rate, as correct as it is possible to make it from the information they had.

Mr. WILLIAM FORSYTH—In reply to Mr. Wells' question, as to the proper diameter of compound cylinders, when you want to meet the power of a simple engine, the English designers and the German designers gave us a rule, quite early in the day of compound engines, which was to make the compound high-pressure cylinder one inch larger in diameter than the simple engine that you want to make it equal to, and within the small range of diameters which we use in high-pressure cylinders this rule seems to have worked out very well. It is near enough, because if you need a little more power you can make it up in the extra pressure.

I would like to take this opportunity of correcting rather a general impression in regard to the experiments made with compound engines on the C., B. & Q. road last year, and the report which I made on those experiments. That impression is, that the results of the tests were unfavorable to compound engines. That is, as a general statement. But the fact that we settled for ourselves was, that in fast heavy passenger service the compound engine was not economical, and that we could not decide on that type for that kind of service, but would prefer a simple engine for that service.

Now, I think that the two important conclusions to be gained from this discussion to-day, and from the report of the committee, are simply these: That the experience so far largely points in the direction that compound engines will not show an important economy in fast passenger service. As Mr. Barnes has said, the indicator-cards taken under such conditions do not show us any lines at all from which we would find a distribution of steam to produce any better economy, if as good economy, as from a simple engine of the same design. The other fact is that, up to the present time, there seems to be no doubt whatever, from the numerous experiments that have been made, and the conclusions of the committee, that compound freight engines are economical, and probably more so than the committee have stated in their report. That is the opinion I expressed last year in this discussion, and we are now building compound freight engines in our shop at Aurora.

I was very much pleased with Mr. Vauclain's discussion of this report, and am disposed to agree with him in the systematic way in which he took up each point and discussed it. But the trouble is that he claims too much for his engine, and when he says that it has proved economical in fast passenger service, I do not think that carefully conducted tests will show that to be the case. He also claims too much when he says that fast passenger speed is only possible with a piston-valve. I was disposed to agree with him when I read the letter he wrote to that effect to the *Railway Gazette*, and thought it was an important point, but the experience that the New York Central Road has had with a plain, old-fashioned engine, you might say, except in regard to its size, with a plain slide-valve and high pressure, shows that very high speed can be obtained with the slide-

valve. The Schenectady Locomotive Works are running their engines with high pressure and with slide-valves. I think it is quite a creditable thing, though, to the Baldwin Locomotive Works and to Mr. Vauclain that they have made such a success of the piston-valve and have been able to obtain such high speed by its use. (Applause.)

Mr. VAUCLAIN—I desire to thank Mr. Forsyth for the high compliment he has paid me, and I only wish to say in regard to what I claim for fast passenger service that it was not what I claimed, but what is claimed by people who are using our engines, and to substantiate my claim I will suggest that the president call upon Mr. Anderson, of the Central Railroad of Georgia. One engine there hauls a train 300 miles and return. We would like very much to hear from anyone in regard to the service which these engines are doing.

Mr. WELLS—Mr. Forsyth spoke of the rule given us by English mechanical engineers in regard to the increased size of the high pressure cylinder in a compound locomotive over its equivalent in a single engine. They gave it as 1 inch. But if you will make the calculation, the difference between a cylinder 12 inches and a cylinder 13 inches in diameter amounts to about 18 or 19 per cent., but when you go up to the difference between a 20-inch and a 21-inch cylinder it is only 9 per cent., so that that rule is not a correct one for the different sizes. It may be correct enough as between a 12 and a 13, or between a 15 and a 16, but it is not sufficient when you get up to a 20 and 21—those higher diameters.

Mr. MEDWAY—One very important matter to me has been omitted—that is, the capacity for throwing sparks. I would say that in our case we have got good results from the compound in regard to that. I would like to hear from others.

Mr. MITCHELL—In regard to throwing the sparks, I had occasion a few days ago to send my man on the hill, and in talking with the track sub-foreman he said that with the consolidation engines formerly used on that hill for pushing trains it required one or two engines in the dry season to watch the sparks and put the fires out. Since the compounds have been used there, a fire was something never known. I think that speaks very well for the compound.

The PRESIDENT—Gentlemen, I will say in reply to the request the gentleman made a few moments ago that the chair give his opinion as to the relative merits of the compound and simple engines, that I can [illegible] reply there is nothing that I can say now that would add to the [illegible] information you already have on that subject, and it would be [illegible] for me to take up the time of the Convention. It would [illegible] thing to your present information. I will therefore say nothing [illegible] this time.

Secretary SINCLAIR—I move that the discussion be closed.

The motion was carried.

DISCUSSION ON IRON AND STEEL.

The PRESIDENT—Gentlemen, you will remember we had a very interesting discussion yesterday on the question of tests of iron and steel, and it was reluctantly disposed of. We sent out for Mr. Fox, who is an expert on the question, but we were not able to find him. But I see that he is with us this morning. Mr. Fox is not a member of this association, and it is only by unanimous consent that he would be permitted to speak. Now, if you would like to hear from Mr. Fox, he is present and prepared to say something on that subject, and a motion to permit him to speak will be in order.

A MEMBER—I move that Mr. Fox be requested to address this association on the subject of tests of iron and steel.

The motion was carried.

The PRESIDENT—Mr. Fox, will you please address the meeting?

MR. SAMPSON FOX ON STEEL.

Mr. SAMPSON FOX—Gentlemen, I consider you have done me a great honor in asking me to say a few words on the all-important question of the material of which our boilers have to be built. I would, in the first place, ask you to consider that I do not come here in the character of a teacher. I do not come to teach any one his business. But happening to be in this country for the last few weeks, I have met a number of gentlemen who are interested in the question of firebox plate. Now, steel plate for the purpose of fireboxes at sea has been with me a considerable manufacture for a long number of years. I think if I was to say to you that I have turned out, within the last fourteen years, at least 100,000 tons of firebox plate, which have been used solely for the purpose of making steam furnaces, I should be within the mark. You know very well that a man who has done a large amount of work must necessarily have made a large number of blunders, and it is out of the blunders that he finds what may be considered the best way of keeping on the straight path. (Applause.)

First of all, I would put what I have to say more on the basis of what we consider is right at the present time. There may be great improvements yet; I dare say there will be. But what we consider in firebox plate making, first of all, is to select very pure materials. That is to say, we will take pig iron which contains in nature the smallest amount of sulphur and phosphorus. We do not mind very much about the amount of silicon. We do not mind very much about the amount of carbon. But we must have these two enemies, sulphur and phosphorus, away from the material that we start with. Further, we consider that it is necessary to know exactly the composition of the fuel that we use in every part of the work, so that the gas from the fuel has the same value in purity as the pig iron that we have already started to work with. Bringing these together, and both being cleared from those very serious enemies, sulphur and phosphorus, we may then go to work and expect to obtain a fair, reasonable result. But it is important, also, that the linings of the furnace, such as the sand and the

ganister that you use. and also the bricks of which it is composed, shall be as pure as the gas and the pig iron.

Now, bringing these materials together in their various forms and getting the chemical actions of one on the other, none of them possesses the qualifications to bring in with it something that it never contained, and therefore when the action is thorough there is no doubt that after such a start you will get as a result a pure plate. That is to say, that it should have for firebox purposes about .11 of carbon. You may put from .50 to .55 of ferromanganese into it, but you should get your sulphur and phosphorus down to as low as .04 to .05. If you do that you will find that you have got a material which, if properly manufactured from the ingot down to the shorn plate, will do almost anything as regards standing fire and every other manipulation of turning it into a first-class boiler.

But there are some considerations to be given to the manipulation. I believe in some factories in this country it is thought not necessary to put any work on to the ingot. That is to say that the ingot is rolled direct into the plate. We hold a different opinion. We prefer for the best class of work to hammer the ingot, reducing it from about a 15-inch thick ingot down to about 5. Now, that ingot is hammered on the flat and it is hammered on the edge and the ends are cut off. But even after that it is necessary to exercise care in reheating such a slab. because we all know that we are troubled at times with lamination in the plates and it generally occurs at the end of the plate. That has been clearly proved over and over again to be the overlapping of one side of the plate over the other, and in practice you will often find that men who are rushing their work will bring out their slabs not so well heated on the one side as on the other, and the consequence is that when such a slab enters your roll, the soft side will run ahead and draw farther than the hard side, and the hard side is, as it were, rolled partially into the soft slab. Consequently, you will find that one part has overlapped the other. This may not show itself, even when the plate is short, even when it has been annealed, but still it will show itself in working some day. If that same chemical contact does not exist from the beginning to the end, and in every cubic inch of the plate, it will show itself when it comes to deal with the expansion and contraction due to its work in the boiler.

Now, it should be the question for the user of such plates to buy only on the condition of certain mechanical tests and chemical composition. If a committee were to look fairly into the different tests set forth either in France, or in Germany, or in England, they would find that there is a steadfast growing of the principle of standard tests, especially for firebox work. Those tests need not be anything further than specified, and inspectors ought to see the plates tested on these grounds. The Board of Trade and the Admiralty of England, and many other associations such as Lloyds, and Bureau Veritas, set down that a piece of material shall be cut from a plate which shall in 10 inches of length extend from 20 to 25 per cent. The British Admiralty is 25 per cent. as the minimum, so is the

Russian Admiralty, so is the French Admiralty. But the Board of Trade go down as low as 20 per cent., so that that elongation shall be, whether 20 or 25 per cent., the elongation taking place within 10 inches of length pulled in an ordinary testing machine. In addition to that the Admiralties fix a standard of tensile strength. They say it shall not be more than 25 tons to the square inch, and they usually say it shall not be less than 24. That is, our gross tons of 2,240 pounds. Now, if you are bound within the range of a ton, you have got to have your chemical composition pretty uniform all through all the plates you make, and if you get an elongation, such as I have mentioned, of 20 to 25 per cent., that is a material that will do very good work.

There is another point that I might mention in practice. We have found by experience that there should be a little difference in the amount of carbon according to the thickness of the plate that you are making. For instance, if you start with .11 for a ¼-inch plate and you are going to make ½-inch plate which shall bear the same 25 tons and not lower than 24, and with the same elongation of 25 or 20 per cent., then you must put a little more carbon into the ½-inch plate than you did into the ¼-inch plate, and so on with the ¾-inch plate, and so on with the inch plate—a little more still. If you keep the same carbon and expect the same tensile strength, you won't get it, because your material is made more dense in rolling down to a ¼ plate than to a ½-inch or ¾. These are features that have led to pretty fair success on our side. I have made many thousands of tons of plate where we have undertaken to be only not more than ten hundred-weight on either side of a given point. In our thickest shell plate, at 27 tons, it would not be more than ten hundred-weight on either side of the 27, and that can only be done by watching the carbon as to the thickness of the plate. We have been very successful indeed by varying the carbon.

I am sure that in this country you have all the raw material that any one else has, in coal and in pig iron and in fire clay. You have all the conditions of purity of material, and if the purchasers and users of the plate were to lay down a standard of purity and strength and elongation, that would be the very first thing to do in order to get that uniformity in your firebox plate which is so much required. Of course, at first your inspectors would have great trouble. They would have to throw out a good many plates. No one has any idea of the want of uniformity in plates who has not acted as an inspector to the firms which are not so closely pinned down. The maker finds that he has got a good lot of material thrown out, and there is nothing like having such a lot of material thrown out to make him find out what is the right thing for him to do.

I am very pleased to have had the opportunity of speaking to you. I want you clearly to understand that I do not say what I have said in any spirit other than as a suggestion drawn from what we have learned in our experience on the other side, especially my own firm. (Applause.)

Mr. John A. Hill—I should like very much to have Mr. Fox tell us the simple way in which he determines the amount of carbon in his steel, which

I saw practiced in his works, and also the way in which he cuts his test-plates.

Mr. Fox—We have what is known as a color-test. Now, a color-test is a known weight of a chemically pure iron, or a known weight of a steel, with a known quantity of carbon. Before the process is started we want to know that we have got the best line of pure iron ore, with such an amount of ferromanganese as we decide upon to mix with it, and get our required quantity of carbon. Unless we know that we have got a pure iron in the furnace, tested by another pure iron, there is no possibility of arriving at the point by mixing a further quantity of ferromanganese with it. To do that, as I said, we have a known small weight of pure iron dissolved in acid and a known weight of water mixed with it. That produces a rather crimson-colored liquid, and more water added to it brings it forward to yellow. Well, we take our supposed pure iron from the furnace and we weigh the same quantity and dissolve it with the same quantity of acid as the other, and then fill up two test-tubes, that are graduated, with such a quantity of water as will bring both the liquids to the same shade of color, looking at it upon a sheet of white paper. The result is that when you read off the difference in the water on the scale of the two tubes, that is the difference in the carbon, less or more, between one and the other. One is considered to be without carbon entirely and the other may have a little in it. But as to getting them both pure, if you cannot get any nearer with your furnace, you then calculate what it has in it at the time and make the difference due to the larger quantity of water in one tube over the other, having filled them both to a point where they are exactly the same shade. That is a very ready method. It can be done in ten minutes. Therefore, your furnace does not suffer any delay while you are carrying the experiment out. Then, again, if you take your pure iron, you want to know what carbon you have in a piece of finished material. Use it in the same way, and read off what the differences are and the quantity of water, to get the two shades the same. In regard to the other point, taking the test-pieces crossway, there is no doubt that you will always get the best result from that way of the plate that has most work put on it, rolling it lengthwise. But we do not quite want that. We want the worst conditions of the plate; that is, to take your test-piece off crosswise. We always adopt that system, and it is a satisfactory one, inasmuch as when you have got your standard of density and elongation on the crossway you are much more sure to be right on the lengthway. (Applause.)

Secretary Sinclair—Mr. President, as most of our members are engaged in inland pursuits and are little familiar with what is going on in the marine line, and as some of them may know little of what Mr. Fox has done for the engineering world, if you will permit I would give a few outlines of what I know of Mr. Fox's work, having learned a good deal about it when I was connected with marine service.

When Mr. Fox began his life work on marine boilers, all furnaces were plain cylinders or cylindrical tops—crowns, and the prevailing pressure was

70 pounds to the inch. It was impossible to raise that pressure higher without having trouble with the furnaces, and it seemed that the marine engineers had reached the limit so far as pressures were concerned. They could not have higher pressures in the cylinders, because they could not get boilers with furnaces to stand the heat necessary. Mr. Fox began making furnaces of different sorts for land and marine work, and while looking over the reports of the insurance inspector of boilers he was struck with the very weak point about a marine boiler, in the furnace, and it struck him that by corrugating the furnace he would get very much greater strength with a given thickness of sheet. It would also enable them to keep down the thickness of sheets, which was increasing to a great extent, with the view of getting more strength, and lead more readily to burning of the sheets. He began introducing those corrugated furnaces and they were a success from the beginning. They were scarcely introduced before the leading engineers of the time recognized their merit and their possibilities. That furnace has enabled marine pressures to be raised from 70 pounds to 200 pounds to the inch. It has reduced the steam used per horse-power from about 5 down to perhaps 2½ pounds per horse-power, and in the best forms of engines down to 1½ pounds of coal per horse-power per hour. The saving of fuel to the world has been enormous. There are now over 70,-000 Fox furnaces in use in marine boilers. The saving to the world of coal from that alone is no doubt 2,000,000 tons per year or over. These points will give you some idea of what Mr. Fox has done for the world. (Applause.)

Mr. Hill—The question has just been asked me what interest I have in the Fox works? I have none. I believe we can make just as good boilers in this country as Mr. Fox can; perhaps better. But we ought to profit by the experience of everybody in the world. Mr. Fox had the peculiar necessity of making the best kind of steel to make his firebox a success. If he had to sell his steel for 3 cents a pound, as our steel-makers do, I do not believe he would have made a success of it. He put up a large factory and experimented for fourteen years to make the best steel to do the work, not to sell in the open market. That is what brought his success. Whenever any inducement is held out to any of our large steel-makers in this country to produce that kind of steel they will do it.

Mr. Henderson—I would like to ask Mr. Fox what that steel is worth per pound?

Mr. Fox—We are selling that material for about £9 per ton of 2,240 pounds. Of course, you could not produce the same class of material at the same price in this country.

Mr. Blackwell—I think I understood Mr. Fox to say that if the sulphur and phosphorus were reduced from .04 to .05 that we would get a material that would give satisfactory service. I would like to ask Mr. Fox what would be the result of reducing the phosphorus and sulphur still lower; say the phosphorus to .2 and the sulphur to .025 or .030? Would it give any better material for locomotive firebox furnaces?

Mr. Fox—Yes; there is no doubt it would. It would give better results as regards cracking or starring or anything due to the application of heat on the one side and water on the other. But when you get down to completely pure iron, then you lose the dignity of the material to the extent that other difficulties creep in, such as grooving and pitting of the plate, due to various changes of water. These constituents in small quantities, where they do not interfere with the ductility of the material, are in my opinion a considerable safeguard against what occurs when a very pure iron is placed in contact with water that is being made into steam—such as pitting and grooving. We have been troubled with that, with some classes of waters in the marine boiler. But it can be got over by introducing zinc into the steam space. The zinc by degrees deposits itself over the surface of the plates, and the result is a whitish coloring which seems to protect the plate perfectly from these difficulties of grooving and pitting.

The PRESIDENT—Gentlemen, the noon hour having arrived, subjects presented by the members are the special order. We have a great deal of work to do yet, however.

PROPOSED ASSOCIATE MEMBER.

Secretary SINCLAIR—The following has been handed up:

We, the undersigned members, propose the name of Willis C. Squire, of the *Railway Age and Northwestern Railroader*, as associate member.

WILLIAM MCINTOSH,
W. H. LEWIS,
WILLIAM FORSYTH.

On motion of Mr. Swanston, the application was referred to a committee.

The PRESIDENT—Mr. William McIntosh, Mr. W. H. Lewis and Mr. William Forsyth are the committee. Now, gentlemen, we will proceed to the discussion of the noon subject.

The PRESIDENT—It has been suggested that we proceed with the ordinary business—that of the reports of committees—and defer the noon-hour subjects. I do not like to do that very well, as the noon-hour subjects have always been very profitable, and have been some of the best work of the Convention. But if there is no objection we will go on with the reports. The next report is on Uniform Locomotive Performance Sheets. The chairman of the committee is George F. Wilson.

UNIFORM LOCOMOTIVE PERFORMANCE SHEETS.

Secretary SINCLAIR—This is one of the subjects that was carried over from last year. The chairman of the committee has written saying that he can do nothing better than what he recommended in his report of last year. It is a very difficult matter to establish uniformity in performance sheets while the accounts of different railroads are arranged differently, and

70 pounds to the inch. It was impossib...
without having trouble with the furnaces...
engineers had reached the limit so far as ...
could not have higher pressures in the cy...
boilers with furnaces to stand the heat ne...
furnaces of different sorts for land and ...
over the reports of the insurance inspec...
the very weak point about a marine boi...
him that by corrugating the furnace he...
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That furnace has enabled marine press...
200 pounds to the inch. It has reduced ...
about 5 down to perhaps 2½ pounds pe...
of engines down to 1½ pounds of c...
saving of fuel to the world has been e...
000 Fox furnaces in use in marine boil...
from that alone is no doubt 2,000,000 ...
will give you some idea of what M...
plause.)

Mr. Hill—The question has just ...
in the Fox works? I have none. I ...
ers in this country as Mr. Fox car...
profit by the experience of everyb...
peculiar necessity of making the b...
success. If he had to sell his stee...
makers do, I do not believe he wo...
up a large factory and experimented...
steel to do the work, not to sell in th...
his success. Whenever any induce...
steel-makers in this country to prod...

Mr. Henderson—I would like ...
per pound?

Mr. Fox—We are selling that ...
pounds. Of course, you could no...
the same price in this country.

Mr. Blackwell—I think I un...
phur and phosphorus were reduc...
material that would give satisfacto...
what would be the result of red...
lower; say the phosphorus to .2 a...
give any better material for locom...

... association. It is a
... up and establish some
...ation to be made and

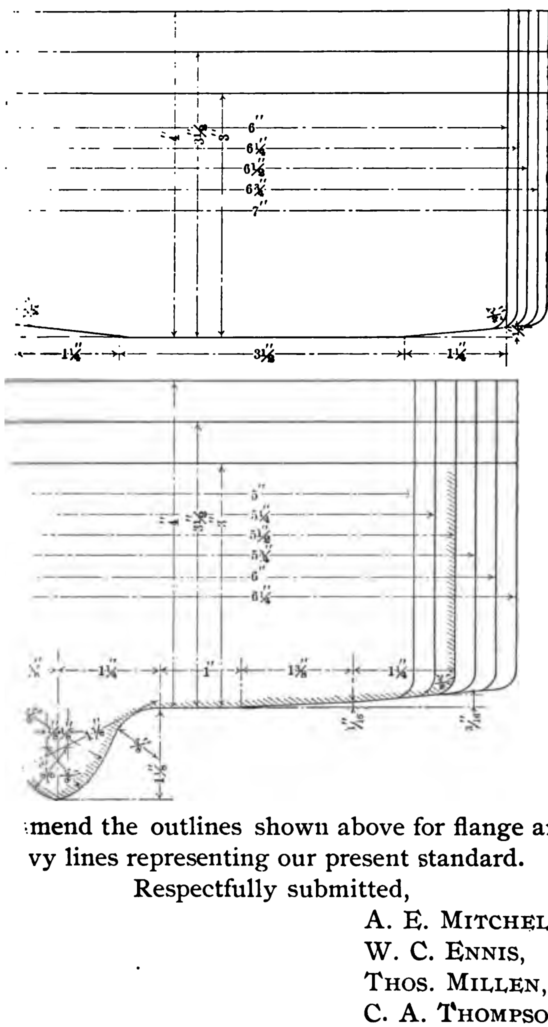
...charged.
...—Standard Diameter of
... Mitchell.
... Mr. Pomeroy to read the
...

... Tires.

... on diameters of wheel
... standard, also to inves-
...mity of rolled outlines of
...llows:
...ject, we find a majority of
...ters of the wheel centers
...ease by four (4) inches,
...nl, 70, 74, 78, 82, 86 and

...formity of rolled outlines,
...mmittee that they had no
...ever, is a very important
...ideration. We must all
...es of tires were to become
... be effected both to the
...he manufacturers, on ac-
...o one contour, so far as
...the carrying of less stock
...f fewer sections of rolls,
...curately that machining
...onsumers, on account of
...livery, thereby enabling
...s saving interest on the
...e invested. Each and
...d take whatever steps
... the Master Mechanics'
...n adopted,
...ting in his

ifies the Master Mechanics' outline of tire and that all
for shop use are made exactly to the standard outline.
r judgment additional widths to the Master Mechanics'
flange tire and a new standard plain tire of several
hould be adopted, and after careful consideration we



mend the outlines shown above for flange and plain
vy lines representing our present standard.

Respectfully submitted,

A. E. MITCHELL,
W. C. ENNIS,
THOS. MILLEN,
C. A. THOMPSON,
L. R. POMEROY,
Committee.

tires. The front and back wheels are flanged and the two middle wheels are bald, and we used a 7⅛-inch tire for the same reason.

Mr. Pomeroy—You will note in this report, where the different widths are given, the relative contour, so far as the flange and the position of the tire remaining on the rail, is the same in each case.

Mr. Marshall—I would like to ask if it is understood, provided this motion is passed, that the association will adopt the sketches as they appear on page 2 of this report? If that is the case, then for each size of plain tire we would have fifteen sections that would be standard, and the same for each size of flanged tire. Now, if the object of adopting a standard is to reduce the number of sections, it does not seem to me that that is accomplished in this case.

Mr. Mitchell—I would say that we found by consulting with the makers of tires that there is an immense number of sections carried by manufacturers, and it seemed as though every railroad company wanted a special tire to suit their conditions. Those who were using plain tires 6-inch and 7 inch, I find to-day that they are 7½-inch, and for flanged tires there are tires being used throughout the country carrying all these measurements from 5 inches up. If these are adopted it will reduce the number of sections. We have locomotives which were built 4 feet 8½-inch gauge and they have to go over a portion of the Pennsylvania road, which is 4 feet 9-inch. Therefore we found it necessary to put on a wider flanged tire than what we used on our own road.

Mr. Gillis—I would like to ask in regard to the design of the blind tire, whether it is intended to keep the middle portion of the tire flat for all widths?

Mr. Mitchell—Yes, sir; that was the intention.

Mr. Swanston's motion was then put and carried.

Mr. Lewis—I move that we adjourn.

The President—Let me say that I have the pleasure of seeing by our secretary's figures that 154 members are present at this Convention—the largest attendance in the history of the association. It is very pleasant to think that we have so many with us. I hope that your work will be in proportion to your members.

The Convention then adjourned until the following day.

A. M.

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these attachments separately to boiler? Is there any provision made to close the connection between steam-chamber and boiler?

While your Committee have been favored with a sufficient number of replies to give them an idea of the practice in vogue by a greater percentage of the largest railroad systems, still the replies were not as complete as might be expected on a subject of such importance, involving the safety of passengers, as well as employés. Many of the more important questions have been evaded in the replies; others have indefinitely explained their practice, and some have given a very full and complete explanation.

The Committee submit below a tabulated statement, giving in a condensed form the replies received, which, in the estimation of the Committee, represents as nearly as can be the methods and manners in which boiler attachments are applied to boilers by different companies.

RECAPITULATION.

Question No. 1:

E. T. V. & G. report least number of openings.
Average number of openings reported, 11.

Question No. 2:

8 Give no suggestions as to how the number of openings could be reduced.
1 Favors both injectors on one side.
1 Recommends abolishing some of the attachments.
11 Favor use of steam-chamber.
2 Favor use of steam-chamber and water column for gauge-cock.
—
23

Question No. 3:

6 Claim the escape of water and steam could be prevented by use of inside valves.
7 By use of automatic valves.
9 Give no opinion.
1 Claims attachments are too light.
—
23

Question No. 4:

9 No experience with inside checks.
3 Now experimenting.
3 No answer.
3 Experience favorable.
2 Experience unfavorable.
3 No experience, but favor same.
—
23

Question No. 5:

14 Think water-glass necessary.
9 Think water-glass unnecessary.
—
23

7 Think automatic valves necessary to protect water-gauge cock.
9 No answer.
5 Do not consider automatic valves necessary.
2 Prefer shield for protection.
—
23

Question No. 6.

18 Use steam-chamber.
4 Attach parts separately.
1 Uses turrets.
—
23

8 Have no provision to close connection.
4 Use ordinary valves.
5 Use automatic valves.
6 No answer.
—
23

From the foregoing, coupled with their own experience and observation, the Committee have decided on the following recommendations, which, in their opinion, are consistent, and will establish a greater degree of uniformity and safety in boiler attachments.

1st. That all connections for conveying steam from boiler, excepting gauge-cocks, water-gauge glasses, check-valves, blow-off cocks, service cocks, whistle and safety valves, be attached to the steam-chamber, connected to boiler by a flange, to be bolted to the top of boiler, or to the back side of dome, and that a self-closing or automatic valve be used inside of boiler or below a point where the connections with the boiler are liable to be broken, and a valve be placed between chamber and boiler. Illustrations of good practice in this respect are shown in Figs. 1 and 2.

2d. The Committee are of the opinion that a gauge-cock with guard-valve inside of boiler is quite desirable, but not knowing of any form of such cocks, which is entirely satisfactory, refrain from recommending any.

3d. The Committee are of the opinion that water-gauge glasses are not a necessity, while same may be a convenience to engineers

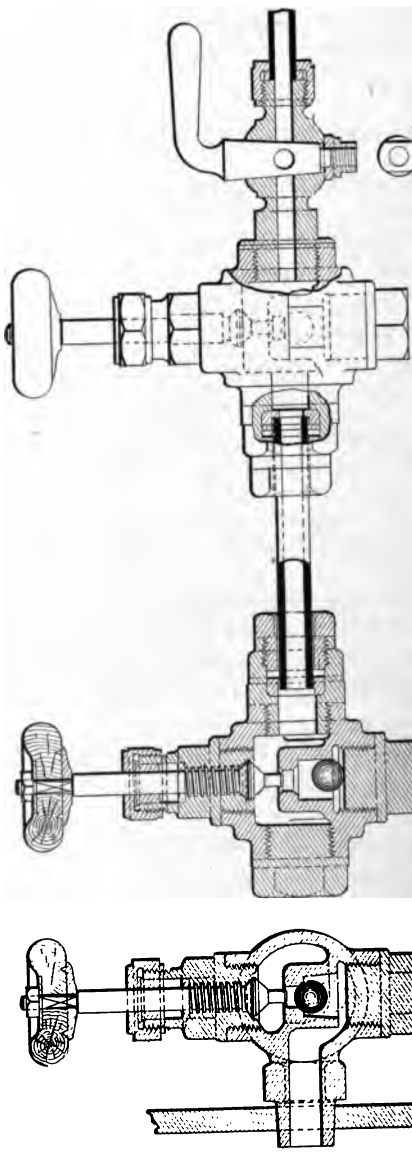


FIG. 3.

Bradley & Poates, Engr's, N.Y.

and firemen, and that when same are used they should be supplied with automatic closing valves, as shown in Fig. 3.

4th. That the check-valves be attached by flanges to the back boiler-head, and the feed-water be conducted to the front end of boiler by a pipe or trough inside of the boiler, or when the connection of check-valves to boiler cannot consistently be made to the back boiler-head, that a double check-valve might be attached to the back side of dome, and the water conveyed from this to the front end of boiler by a pipe or open trough, and that only one opening be made in boiler for connecting the check-valves, this opening to be protected by a guard-valve inside, and a double

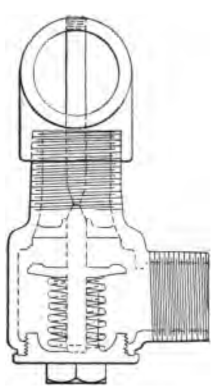


FIG. 4.

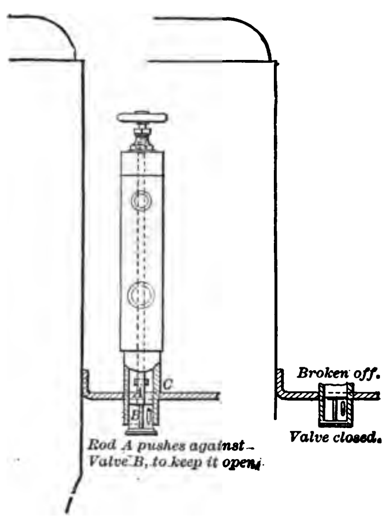


FIG. 5.

"T" pipe with two check-valves, one for each injector, be provided outside. See Figs. 4 and 5.

5th. That blow-off cocks be placed in the front or back ends of fireboxes and not on either side.

6th. That all studs screwed into boiler be made with a weakening groove outside.

7th. That the whistle valves be placed inside of the boiler, and, if not, that a separate guard-valve be provided. See Fig. 6.

8th. That safety-valves be placed in a recess in dome cover

below the top of dome, so as to be protected from injury in case of collision or other accident.

In addition, the Committee wish to direct attention to the fact that the majority of the railroads are now using steam-chambers in one form or another; that while it would be difficult to design a steam-chamber for the uniform adoption of all railroads and to meet the views of all members, it should not require much argument to convince every member of the Association of the necessity of having the steam-chamber, be it of what style it may, as long as it embodies the necessary features of safety.

The Committee are also of the opinion that there is a tendency of making attachments too light, and that a much greater degree of safety could be established by making attachments more sub-

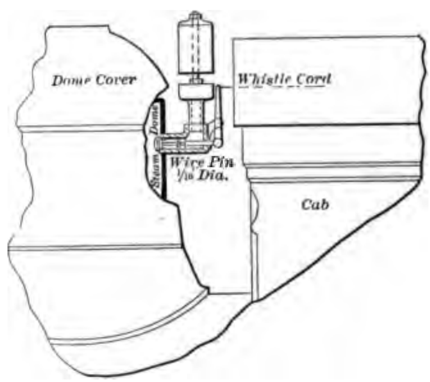


FIG. 6.

stantial. There is also a great tendency of applying unnecessary attachments to boilers, which could readily be abandoned entirely.

The Committee have recommended the use of flange-joint in the application of checks, this being almost universally adopted already, and it no doubt being the most substantial manner of application, less apt to be broken off, and safer in every way than the screw-joint.

The Committee inclose herewith a number of blue-prints received from members, and some prepared by members of the Committee, and while none of them embody the entire recom-

mendations of the Committee, they are all suggestive of the manner in which the ideas in the Committee's recommendations may be carried into effect.

We also send a number of blue-prints, showing old methods of attachments, which should be considered obsolete and unsafe.

The Committee have in their recommendations endeavored, as far as possible, to establish a method of applying boiler attachments which would be safe and efficient, and still not be at too great a variance with the present mode of applying same, and feel themselves under obligations to the gentlemen who have favored them with much valuable and useful information, and wish to express their appreciation and thanks for same.

JAMES MACBETH,
A. DOLBEER,
J. M. BOON,
W. A. FOSTER,
M. N. FORNEY,
Committee.

DISCUSSION ON BOILER ATTACHMENTS.

Mr. SPRAGUE—I move that the report be received.

Secretary SINCLAIR—If there is no one else ready to say anything on this report I wish to make a remark or two on Article 3d of the recommendations. In that article the committee express the opinion that gauge water-glasses are not a necessity in modern locomotive running. They have been considered a necessity and are so regarded on nearly all roads nowadays. The water-glass is a very great assistance to the man running the engine. It is not only a convenience, as stated here, to engineers and firemen, but it is a means of better regulation of the water supply than can be obtained with the ordinary gauge-cocks, and therefore the most advanced men in this line consider the water-glass a necessity. It is not right for this association to go on record as saying that this is not a necessity, for you know when law-suits are brought against a railroad company there is always a readiness to take advantage of anything that has been said by this association that can be used for their purpose. Consequently, I want to put the association on record as favoring water-glasses.

The PRESIDENT—Are there any further remarks on this? I think the points taken up by the secretary are very important.

Mr. BARNES—I would like to subscribe to what Mr. Sinclair says. We had twenty-five engines come on to the elevated railroad in Chicago without water-glasses. We had three burnt crown-sheets right away, and taking the men up for trial before a Board, we found that they claimed that

the gauge-cocks had an unusual sound. The Board, being of a semi-scientific, practical character, said that if a man could not tell by the sound of the gauge-cocks for a dead certainty where the water was, he ought not to be discharged, these being small boilers, while the men were accustomed to large boilers. Therefore we could not reprimand the men as we wanted to, but we had to put on water-glasses.

Mr. HENDERSON—That is something like our experience on the Norfolk & Western. Several years ago it was decided to omit the gauge-glasses entirely. That was followed by a number of crown-sheets coming down. After that we put on two glass tubes—one where the fireman could observe it—and there has been comparatively little trouble since we adopted them.

Mr. MACBETH—In reference to roads requiring water-glasses for the necessity of the engineers, it might be that some of them had bad ears. Years ago we used to have what we called tin-cup engineers, but I believe they are all done away with. They used to have to take a sample of water in a cup to know that the boiler was safe. It was not the intention to recommend the doing away with water-glasses. But I think a majority of the members here to-day, if they look over their locomotives, will find a great many water-glasses that are not taken care of. The committee is well aware of the fact that a water-glass is a good thing if it is well taken care of. They are also aware of the fact that if it is not taken care of it is a very dangerous thing, as has been decided by the courts. There have been a number of suits in which the company has taken the stand that the water glass is not a necessity. We have had crown-sheet after crown-sheet drop with water-glasses, and it has been proved that the men did not take care of the water-glasses. What was the result? They depended on the water glass and down came the crown-sheet. That was the feeling that we had about it. We say it is a convenience to the engineer, but I think you will find as many crown-sheets saved by not having water-glasses as by having them, unless the engineer is of the tin-cup description.

Mr. SPRAGUE—I think it is a step backward to take off the water-glasses, for I think that the engineer ought to have every chance to watch the water in his boiler, and, certainly, many times when he would be occupied and might possibly not try his water by the gauge, if the glass were before his eyes he could see it. I think it a good thing. As to its being dangerous on account of breaking, it has been many years since I have been railroading, but when I was railroading, I found that the glass that we used then would stand about so long. Then the corrosion at the end would fracture it. I found by changing them in a certain length of time, I think six months, that I hardly ever had one break on the road. I took the least time in which one would break and I changed them regularly at that time whether they broke or not, and in so doing I found very few accidents. Then, of course, we did not have the safety-valve in them to prevent the water from coming out when the glass broke, as we have now.

Mr. McINTOSH—I take the position that the water-glass is a necessity, and that it would be a backward movement for this association to recom-

the convenience and safety of the water-glass, and also to combat the idea set forth by the chairman of the committee that it is only tin-cup engineers who need the aid of the water-glass. A water-glass enables an engineer to tell if an engine is foaming in a way that gauge-cocks cannot do. He can also watch the level of the water better than he can with gauge-cocks, and so far as the water-glass getting out of order, every man who is accustomed to it will know by watching the movement of the water if the cocks are getting stopped up. A man who does not know that his water-glass cocks are getting out of order is a very poor engineer. There is no difficulty with the breaking of glasses if they are removed at the right time. A gauge-glass has a life that can be pretty easily ascertained. The steam acts on the lead in the glass and eats it out in a given period, according to the service done by the engine, and it is very easy to find that out and remove it in time to prevent breakage. I am not in favor of the association going on record as favoring the water-glass as an absolute necessity ; but I do not think that the committee ought to have put in an article saying that it is not a necessity, for then those who have anything against it will make sure to use that as a lever against the railroad companies.

Mr. MACBETH—In behalf of the committee, who have given considerable attention and labor to this matter, and also in taking up the remarks of Mr. Clark, I think we ought to try to get these things in a little better shape and not have so much variance of opinion. We worked pretty hard on that, and I do not think that the committee wish to be understood as stating that it is not a necessity. They say—here are fourteen out of twenty-three replies from persons who think them a necessity. Now, there are nine replies from persons who do not think they are a necessity. In taking up the question of this law suit, in which I happened to be subpœnaed, there were some fifteen or twenty of the best mechanical engineers that they could get in the country—a number of them are here now—who were subpœnaed to give expert testimony on this water-glass matter. There was not a man there but said that there was no necessity for the water-glass, and the only instruction the judge gave to the jury was—it has been shown to you here that it is not a necessity to have a water-glass in any shape or form to run an engine ; that they are run with every caution and safety without : and it was on that ground that the plaintiff was non-suited.

Mr. BEAN—I would like to be fully understood as favoring the water-glass where there is bad water. I believe it is not needed where water is good.

Mr. MITCHELL—I would like to ask if any one is using the check-valves on the back boiler-head and carrying the trough inside the boiler to the front end ?

Secretary SINCLAIR—Mr. Foster, I think, can say something on that.

Mr. W. A. FOSTER—My check-valves are not on the back end. They are on the shell of the boiler, about as close up as you can get to a wagon-top boiler. I have got one running that has got a trough about eight feet

Bismarck, and in those localities there is no question in the world but that a water-glass comes very near being a necessity. It not only is a safeguard against the burning of the engine, but it enables the engineer to work his engine to better advantage. As soon as he opens up on his engine strongly the water rises in the glass, and, as Mr. Mackenzie says, it sometimes makes itself apparent by throwing the water out of the stack. But there are times when it is not sufficient to be governed by the fact that she is throwing a spray out of the stack. It becomes necessary at times to ease off on the throttle and let the water settle down to its level, and find out what the stage of the water is in the boiler, and I would very much dislike to have this association take the stand that the water-glass was not necessary, because I think there are localities where it is an absolute necessity.

Mr. J. H. MANNING—I fully agree with Mr. Lewis, that in the West a water-glass is a necessity. It would be a very hard matter indeed to operate an engine on some of our roads without a water-glass.

Mr. H. A. GILLIS—I am very much interested in this water-glass question, for I have two water-glasses on most of our engines, one for the fireman and one for the engineer, and it struck me at first that it was a little unnecessary to have those two glasses. But I was told that it was very necessary to have two glasses, so that in case anything should happen, that the fireman should be hurt, you would have more excuse—that he had a gauge which he could see and was not dependent on the engineer at all. I took that to be all right. I investigated the thing a little further and I did not find on forty engines I examined a single water-glass on the fireman's end of the boiler that was in working order. They were all stopped up and most of them had the glasses broken. In talking to some of the firemen about it, they expressed themselves very forcibly about that glass. They said they did not want it there, that they might be shoveling coal into the furnace and get scalded. They claimed it was a serious objection. Another claim was made by one of our superintendents of motive power. He said that it was a very necessary thing to have. I asked him why. He said that previously they used to have a great many crown-sheets that dropped I said, What do you have now? Well, he replied, occasionally we drop a crown-sheet. I said, That does not save the crown-sheet now, because it does not work. I have no objection to the water-glass, but I do not think we want too many of them on an engine, and I think it would be a good idea if each master mechanic would find out just how many of his water-glasses are operating, especially if he has bad water. Our road runs through a limestone country and our glasses will not run for any length of time. The cocks get stopped up.

Mr. MACKENZIE—It appears to me that this matter of water-glasses is becoming a necessity by education. I am not a very old man, but I can remember when water-glasses were not much in use, and to-day there are engineers on some of these lines that will not use a water-glass. Take Mr. Blackall's railroad, for instance. We must give him credit for having some good engineers on his 400 engines. If we were to get one of his engineers

on our road, I suppose the first thing he would do would be to take the water-glass off. We have got men on the road that do not pay any attention at all to water-glasses. I am not an advocate of doing away with the water-glass, because I think we have gone so far into it now that, with the majority of railroads, it is a matter of education to the men, and the majority of engineers to-day could not run an engine if you took the water-glass off. They have not confidence enough in themselves to know by the working of the engine and actions of the pump how the boiler should be supplied. We have got men on engines who will run an engine 100 miles and not look at the glass gauge, or the gauge-cocks for that matter.

Mr. GENTRY--We have never used water-glasses at all. We have not got an engine in the service equipped with one that I know of—certainly not on my division. I think that our records will show that we have had fewer crown-sheets drop down than any other road with an equal number of engines of the same class—heavy ten-wheel passenger and consolidation engines. It is the rarest thing that we ever have a case of low water. Our firemen are trained to work the gauge-cocks. When they grow up to be engineers it is natural for them to rely on the gauge-cocks. We have got men there who have been running engines for fifteen years who never saw a water-glass, unless they saw it on some other engine. We never had anything happen to lead us in the way of adopting it. We look upon it more as an ornament, or rather a useless appendage—just another appliance to be put into our boiler-head to take up room. We have got almost everything else which is a good thing to have on modern engines.

Mr. LEWIS—In regard to the statement made by this gentleman, that out of forty engines he found nearly all of the water-glasses inoperative, the glasses broken, etc., it does not seem to me that that is anything against the water-gauge. That is a question of discipline on the part of the officers, who are responsible for it. I find no difficulty in keeping the water-glasses in proper working order, and in the mechanical examinations that we subject our men to before promotion, we question them about the water-glass, and we try to explain to each man the necessity of noticing the vibration of the water in the glass to determine whether or not the cocks are obstructed; that it is an important matter at all times to observe the motion of the water in the glass. If there is a water-glass for the fireman, as mentioned by this gentleman, I think it is proper that the fireman should be held responsible for it. I think it is an omission on the part of the officer that he does not see that those water-glasses are kept in good running order. It does not make any difference what action this association takes on this question of water-glasses, I will, as long as I have the power, maintain the water-glass. I am satisfied that I can get better results in the working of an engine with a water-glass than I can from the gauge-cocks. It is not a question of the skill of the engineer in being able to carry water without seeing it. It is a fact that he can see better the state of the water in the boiler by a water-glass than he can possibly determine it by the sound of the gauge-cock.

Mr. SETCHEL—I would like to ask Mr. Gentry if he has any bad water out on his road?

Mr. GENTRY—On some portions of our system there is water that is a little bad. But on the greater part of our entire road we have water taken from creeks and ponds. We use no spring or well water, and all the impurity is simple silt or mud held in suspension, which is easily washed out. We do not suffer from scale to any extent at all. We can run an engine for several years and take out all the tubes from the holes without having to take out a steam-pipe. We have very pure water. It has not been a question of discipline with our people to make them use what we put on the engine. We have no trouble whatever in making them utilize anything that we put on. We do not think we would have any trouble in making them use the water-gauge.

Mr. JOHN A. HILL—My experience has been entirely in running locomotives. In ten years' service on the Rio Grande road I do not think I ran an engine with a water-glass over three months. Almost the entire equipment had gauge-cocks. On the mountainous section of our road we had good water, but in the southern section of the country we had very bad water. I think that this glass question resolves itself into two things; one is care. Gauge-cocks are in good order because the man uses them every day; he is obliged to use them. You put a water-glass on an engine that uses comparatively bad water, and the man has been used to running with the gauge-cock, and he will not let those gauge-cocks alone, but he will let the water-glass alone. If he had no gauge-cocks and was obliged to take care of his water-glass, I think he would take good care of it. I think that a water-glass is a great help. I think a man would be sure to notice a water-glass where he would sometimes forget to feel his gauge-cock, although just as good results are obtained from one as from the other, so far as I can see. But I believe the gauge-glass is an additional safeguard, and for the little cost I believe they are worth having. But in my experience most of the gauge-glasses are very frail and weak, and give trouble from that cause.

Mr. SPRAGUE—I would like to say one word in regard to the legal aspect of the thing. It has raised in my mind the question whether we are here to give our best judgment as to what is proper and safe for locomotive practice, or whether we are here to evade legal obligations; whether we are here to advance the interests of the locomotive, or whether we are here to whip the devil around the stump and avoid law-suits. I do not think that ought to be taken into consideration. If we are satisfied that a thing is an advantage to the locomotive we ought to advocate it regardless of law-suits.

The PRESIDENT—Do you still desire to press your resolution, Mr. Setchel?

Mr. SETCHEL—I should like to present it.

Mr. Setchel's resolution was adopted by a rising vote.

On motion the discussion was closed.

Discussion on Locomotive Tests.

The President--We will now return to a subject that we have deferred two or three times already, and that is, "Standard Tests for Locomotives." We want to dispose of that, gentlemen, because it was made the special order for this morning. We deferred it until we should have a larger number in attendance. We will now take it up. It is suggested that Mr. Forsyth open this subject.

Mr. William Forsyth—We have occupied more than an hour this morning in talking on water-glasses. I hope you will have patience with me for about fifteen or twenty minutes, or less, in talking about this report on tests of locomotives. The work of the testing department of railroads is growing in amount and importance every year. The proceedings of our railroad clubs and of our association are filled with reports of tests of railroad material and railroad machines. The locomotive is the most important thing which concerns this association, and certainly the tests of locomotives and the report of your Committee on Testing Locomotives are worthy of attention. I will ask you, then, to listen to a short account of what the Committee of Mechanical Engineers and your committee have done on this subject.

In 1890, the Mechanical Engineers' Society appointed a Committee on Standard Method of Testing Locomotives, composed of Mr. Dean, Mr. Cloud, Mr. Vogt, Mr. Stirling, Mr. Denton, Mr. Soule and myself. That committee made a report in 1892, and this report, which was presented to you, is a revision of the report by Mr. Dean and Mr. Lauder. In 1892, Mr. Barnes, Mr. Barrus and Professor Goss were added to the Mechanical Engineers' Committee. Now, the report to the Mechanical Engineers' Society was presented as a preliminary one, and since that, a few weeks ago, it was revised at the Chicago meeting, and Mr. Dean, who was present at that meeting, agreed that his report, which was then in the hands of the secretary of the association, would also need revision, and for that reason, when the report came up on Monday, he was quite willing that it also be presented as a preliminary report. Now, the most important thing which we have added to the Engineers' report is the section on shop tests, of which I would like to read a synopsis :

"Shop tests, as distinguished from road tests, involve the operation of the locomotive to be tested while jacked up, or otherwise arranged to allow the running of its mechanism without a corresponding movement of the locomotive as a whole. Such tests are recommended, and their necessity is urged, because of the facility, when once provision is made for them, with which they may be conducted, the accurate methods of observation which they permit, and the means they furnish for investigating elements in locomotive performance which cannot be satisfactorily developed on the road. Shop tests will not make road tests unnecessary, for it is by the combination of both forms that the fullest information will be obtained ; but it is evident that where such a combination is employed, many of the determinations made in the testing shed will apply to the conditions of the road, and that the road tests may, as a consequence, be much simplified.

"In stationary practice, the necessity for constant conditions during a test which is to serve any purpose beyond that of simply giving the power of the engine, has long been recognized. For example, if the performance of two stationary engines is to be compared, the engines are tested under conditions similar in every particular ; otherwise the comparison is not a fair one. Or if it is desired to study the effect of a change in the method of operating a given stationary engine, tests for comparison are made both under the normal and under the changed condition ; but in both cases, all things are the same save the one factor the effect of which is to be investigated. If this condition is not observed, and the speed in one case is materially changed from that of the other, or if there is a difference of steam pressure, or a difference in the number of expansions, when neither of these factors constitutes the subject for study, difference in the performance of the engine is as likely to be due to these variations as to the particular change the value of which is to be tested.

"These recognized principles governing all experimental study of the action of stationary engines, have for obvious reasons been difficult to apply in testing locomotives. A standard train, use of the same line, and adherence to schedule time, all as recommended in the preceding pages of this report, will do much for road tests, in this direction. But when all precautions have been taken, there still remain conditions which are variable in character, the effect of which must be reduced by repeated runs.

"The necessity for test work of a high order is emphasized by the fact that the real difference in the economy of different well-designed locomotives of the same size, when employed in similar service, is not great. This fact appears to remain true even when both simple and compound engines are included in the comparison. If the steam engineering problems involved could be worked out by tests which would leave no doubt as to what these differences are under the best possible conditions, locomotive designers would have a much more definite starting-point than at present, and the science of locomotive engineering would be materially advanced.

"It is from such considerations as these that the value of shop testing becomes most apparent. The ease with which, in such tests, the same conditions can be maintained throughout a run, and the certainty with which these same conditions may be duplicated from day to day, are important factors in their favor.

"So little has been done in shop testing up to the present time, that it would be unprofitable to attempt to prescribe special rules for conducting them. In some cases, such tests have been made by merely backing the engine clear of the track and absorbing its power by belts or brakes upon its drivers, the whole machine being properly secured against vibration. Such a plan, if well carried out, will serve excellently to give the boiler and cylinder performance, but the difficulties in absorbing power are great.

"The most complete arrangement thus far proposed, is that developed by Prof. Goss, for the engineering laboratory of Purdue University, and described in detail by him at the San Francisco meeting of the society.*

* An experimental locomotive, No. 490, page 427, Vol. XIII.

"The locomotive at Purdue is a four-wheeled Schenectady engine of the following dimensions:

"Cylinders, 17 inches diameter by 24-inch stroke.

"Driving-wheels, 62.8 inches diameter.

"Weight on drivers, 56,000 pounds.

"Total weight (no tender), 85,000 pounds.

"Heating surface, 1214.4 feet.

"Grate surface, 17.5 feet.

"Each pair of driving-wheels rest upon a pair of wheels 63.07 inches in diameter, fast to an axle supported in bearings on a fixed foundation. A disk of cast iron, 56 inches in diameter and 3 inches thick, is fastened to each end of each of these two axles outside of the supporting wheels. These disks are inclosed in a water-tight case, loose upon the axle, and prevented from rotating by links fastened to the foundation. Annular flexible sheets of copper divide each case into three water-tight compartments. One compartment, on the center of the case, contains the cast-iron disk fastened to the axle, one between each vertical side of the case and one sheet of copper. Water being circulated through the two outer compartments, at certain pressures fixed by regulating inlet and outlet cocks, causes the flexible copper sheets, or diaphragms, to hug the cast-iron disk with sufficient force to create a frictional load, or resistance, to the revolution of the latter, sufficient to absorb the power exerted by the locomotive.

"The draw-bar of the latter is coupled to weighing-levers in the rear of the cab platform, which may indicate either the pulling or the pushing force exerted at this point.

"The truck-wheels of the engine rest free upon a short section of track. Measurement of power is made by indicators applied to the steam cylinders, revolution counters applied to the rear driving and supporting axles, and by weighing the force exerted at the draw-bar. No attempt is made to measure the amount of power expended in friction between the copper diaphragms and the disks upon which they act, their action being simply that of adjustable brakes, which absorb the work of the engine so that it may be run at any desired load and speed of rotation.

"Very complete arrangements are provided for measuring coal and water, force of draft, temperature of smoke-box, degree of dryness of steam, waste of injectors, etc.

"For the purpose of inspecting this plant and of witnessing a test, a meeting of the committee was called at Lafayette, on February 23, 1893. On that occasion the engine was run for two hours at a speed of twenty-four miles, while developing 453 horse-power. The brakes absorbed the power without the slightest difficulty.

"After running half-an-hour, the oil circulating through the middle compartment of the brakes had assumed a temperature easily borne by the hand, and no further increase of temperature occurred during the run of two hours. The trial might have continued, apparently, for an indefinite

period, without any disturbance of the uniformity of the conditions. The fore-and-aft vibration of the engine, at twenty-four miles an hour, was less than a tenth of an inch. The point of the cow-catcher vibrated laterally with an easy motion through about three-eighths of an inch. No other movement of the engine was visible.

"The draw-bar strain was so steady that the weighing-lever was easily kept poised between its stops.

"After the above trial, the engine was run at about fifty miles per hour for about fifteen minutes. The vibration at the draw-bar was considerably increased at the higher speed. A more perfect balancing of the engine has been accomplished since their meeting; this vibration has been reduced to an amount that is insignificant, even for speeds considerably above fifty miles per hour. This being accomplished, your committee believe that there are few elements in the performance of locomotives which cannot be determined by such laboratory arrangements as are at Purdue University, with greater accuracy and far less expenditure of time than by attempting measurements of engines upon a railroad.

"In concluding this portion of the report, your committee would summarize points of advantage to be gained by the adopting of the plan of shop testing, as follows:

"1. It insures the constancy of conditions.

"2. It makes whole parts of the whole plant readily accessible, and permits the application of accessory apparatus of every sort.

"3. It increases the possible accuracy with which observations may be taken.

"4. It affords exceptional opportunities for investigating the action of the mechanism when under speed.

"5. It is comparatively inexpensive."

Now, in defense of this method of testing, I will say that I am very glad that I have had an opportunity to read this after the discussion on compound engines yesterday, for I think that that very discussion and the report of the committee emphasize the fact that road tests of engines are not sufficiently accurate to determine these fine engineering points which come into tests of compound and simple engines, and as a practical thing I will read a recommendation of Professor Denton, who is a member of the Mechanical Engineers' Committee:

"I suggest the following thought as a basis for some possible action of the committee in regard to the application of our standard code for a series of laboratory tests.

"The attempts to measure the relative economy of compound and simple locomotives thus far made, I believe, make the situation about as follows:

"Mr. Barrus found about 10 per cent. greater economy for a Vauclain compound than for a simple engine in freight service, and none in passenger service. The Milwaukee tests indicated about the same results. The C., B. & Q. tests show upward of 20 per cent. greater economy for simple

passenger than for a Vauclain compound. Hudson's tests of two-cylinder compounds indicate upward of 20 per cent. superior economy for the compound than for the simple engines for both passenger and freight service. Dean's tests of two-cylinder compounds indicate upward of 30 per cent. greater economy than simple engines for passenger service.

"The results in each case are accepted as reliable, or as settling the question of the relative superiority of economy of the compound *versus* the simple engine, by only the particular parties most directly concerned in each particular case, and very little headway appears to have been made towards any general agreement on the subject.

"I believe that tests of economy in road service will continue to be indefinite to the extent of at least 15 per cent., and that, therefore, if a few standard engines could be taken to a testing plant like that at Purdue University, and their performance recorded under a series of cut-offs and speeds, the opinions of all interested in the relative economy of the two types of engines would be made to agree to a greater extent in a few months than will be the case in as many years without such an investigation.

"The apparatus which Prof. Goss has perfected puts the success of such an investigation beyond reasonable doubt. If it was removed from his laboratory, and set up in an isolated building at Purdue, and funds placed at Professor Goss' disposal, under the direction of a joint committee from the Mechanical Engineers' and Master Mechanics' Associations, a half-dozen or more selected engines could be successively sent there, and tested at intervals of, say, six weeks, without interfering with the instruction exercises of his laboratory, as would be the case, I presume, with his apparatus as now located. An investigation of this character would, I believe, yield results of sufficient practical importance to railroads to warrant their subscription to a fund of, say, $15,000 for its consummation. This fund would cover the cost of an inexpensive building, with a small stationary boiler for driving a fan and heating, for coal, for the services of a corps of assistants of Professor Goss' selection, and some salary for the latter's services in directing the work.

"Would it not, therefore, be well for our committee, and the Master Mechanics' Committee, to recommend the appointment of a new joint committee to arrange with the authorities of Purdue University in regard to their co-operation for carrying out such an investigation, and to solicit subscriptions from leading railroads for the purpose ?"

Now, the Mechanical Engineers' Society are ready to go into this thing, and I have brought it before you this morning to see if you are. I have a letter from Mr. Denton saying that Prof. Hutton is of the opinion that the Mechanical Engineers will not only indorse this idea, but will subscribe to a fund for its execution. I am sorry that Mr. Lauder is not here, because he has investigated the subject to some extent. He is chairman of your committee. He promised if he came here that he would strongly indorse the idea of making these shop tests. I hope that the master mechanics who live in Indiana and Ohio will go down to Lafayette, and I know that

Prof. Goss will be glad to make a run for them if they will make an appointment.

With this explanation, gentlemen, I leave the question in your hands.

Mr. HENDERSON—I think that is a matter of great interest to all of us, and of great importance, and I certainly hope that we will take some action that will look forward to bringing about the result which Mr. Forsyth has explained. There is no question to my mind that locomotive tests are about the most unsatisfactory that we have to make. I have conducted quite a number recently. In one case we had five engines fitted with a certain device, and five engines of the standard type. The trial lasted about one month. Each engine was given three round trips of about 260 miles, so that made altogether thirty round trips, which we took as a basis for future information, and in those different observations we very frequently found that the difference between two runs of one and the same engine was greater than the difference between the total average of the whole series of tests. We were careful to operate these tests in as similar a manner as possible, but, of course, where you have to look out for the regular traffic of a road it is almost impossible to get a satisfactory system of tests. I would like heartily to indorse this idea, and would urge its advancement, and whatever steps we do take I hope will be taken in a very hearty manner, and follow up the suggestion of the American Society of Mechanical Engineers.

Mr. MITCHELL—I think all of us agree that shop tests should be made between simple and compound engines. Therefore, I would make this resolution :

Resolved, That the Committee on Locomotive Tests be instructed to co-operate with the committee from the Mechanical Engineers' Society in a series of shop tests of compound locomotives, to be made on the locomotive-testing apparatus of Purdue University ; second, that the Executive Committee be instructed to provide funds to pay the necessary expenses connected with such shop tests, and solicit subscriptions for this account from railroad companies and locomotive builders, the amount not to exceed $5,000.

Mr. D. L. BARNES—In order to prevent any misunderstanding as to the scope of these shop tests, I would like to describe what I saw at Purdue University and as a member of the committee. The locomotive is mounted on a pair of carrier wheels exactly like a pair of locomotive drivers. It is provided with the same force, makes the same noise and acts exactly as a locomotive does on a road, excepting such things as pertain to the road-bed. I have never been an enthusiast for shop tests, believing that there are many things that cannot be settled in a shop, but there are a great many other things that cannot be settled on the road. For instance, no one knows how to set the valve for a compound locomotive, so far as I know, to get the best results. No one knows how large to make the receiver, or the proper ratio between the cylinders of high and low pressure. The two-cylinder compound locomotives are giving lots of trouble for the lack of that knowledge, and four-cylinder locomotives are giving a lot of trouble

because the valves are not properly arranged. We have not yet seen, as I said the other day, an indicator-card from a compound locomotive at sixty miles an hour that is a credit to the engine or that is as good as a card taken from a simple engine at the same speed. It has been asked whether it is economical to run a locomotive with the throttle partly closed or wide open. That question was settled by the Purdue University tests last year. They tried that test, wire-drawing from 180 to 140 pounds. As had been predicted before, the wire-drawing produced superheating. The superheating was as much as twenty-five degrees, but the economy fell off immediately. The loss of potential, or the loss of possibility of doing work by losing pressure due to wire-drawing, makes a loss of 20 per cent. in the efficiency of the engine. In every case where the dry pipe pressure was 60 to 80 pounds less than that in the boiler, the loss was from 15 to 25 per cent. Such a question as that is very much better settled in the laboratory.

Then, again, in regard to counterbalancing. We have never known, so far as I am aware, just what to do. This Schenectady engine was built with great care. They are known to make very well counterbalanced engines. But she would not run in the laboratory. At fifty-five miles an hour she got dangerous to the apparatus. When the engine went one way the counterbalance went the other. With the pointer on the engine you could see right away what the trouble was. They put on more counterbalance and the engine worked very satisfactorily.

The temperature of the smoke-box is another thing we want to know more about. The pyrometers we have used are wholly unsatisfactory. They vary as much as 200 degrees when put in the same smoke-box and under the same conditions. At the University they use a copper ball which they put in next to the flues. They know the weight of the copper ball. They drop it in water when it comes out, and in that way they get a record of the temperature.

Another interesting thing they found down there was the lifting of the drivers due to the counterbalance. I got down under the machine—it is very accessible—and I could see in between the drivers and the carrier-wheel when the counterbalance was up. But, to settle that question, they fed a wire around between the two wheels and first found that the wire was flattened down when the counterbalance was down. When the counterbalance was up the wire passed through whole, showing that the driver does not lift from the rail. These are only a few questions that can be settled in the laboratory that cannot be settled on the road. This is a very expensive piece of apparatus. No one railroad company would feel justified—unless it was very wealthy—in building it. It is only by the joint action of railroads and locomotive builders that these tests, which are very necessary, can be carried out.

Mr. Gillis—I indorse most heartily Mr. Mitchell's resolution, but I would like to have one change, and that is that this test be comparative with simple engines.

Mr. Mitchell—I should have mentioned simple engines in the resolution. That was an omission.

The PRESIDENT—You agree with that? You accept the amendment?

Mr. MITCHELL—Yes, sir. It should be a comparative test between simple and compound engines of the same type.

Mr. J. W. HILL—I would suggest that the amount of money mentioned is too small. I understand from Mr. Forsyth the amount required is estimated at $15,000. Mr. Mitchell says that we raise not over $5,000. Now, the Society of Mechanical Engineers has no way of raising money except from the members, and they are not all very wealthy. So I would suggest that that limit be raised by us.

Mr. LEEDS—I was just getting on my feet to say about the same thing. If we are going to have this test made there will be a good deal of trouble in getting the engine in and out, and they have got to hire professors. or at least assistants, and we are getting the benefit. The Society of Mechanical Engineers are volunteering to take up this matter with us. Our own committee volunteer their work, and, if we cannot do any better, I am willing to go down into my pocket to balance what our committee is doing for nothing. Twenty thousand dollars is little enough for that job.

The PRESIDENT—As the Executive Committee are asked to provide the funds for this experiment, I would ask Mr. Sinclair, our secretary, to speak for the Executive Committee as to what he thinks he can do toward the collection of the sum.

Secretary SINCLAIR—I have not made any specific inquiries on this subject, as I did not know that it was coming up. I have no doubt whatever that the Executive Committee can succeed in raising $5,000 from railroad companies and locomotive builders. I do not anticipate the least difficulty about that.

Mr. LEEDS—The reason I feel like going down into my pocket is this: Mr. Barnes referred to the conditions of the road. I do not think that has any particular bearing, except such as they can overcome. As I understand, with their braking power they can put an engine to work under the same conditions as a grade can give. If we can demonstrate the economy of an engine with a certain percentage of grade, with a certain percentage in mileage of grade, with this braking power, we can develop a perfect engine for those conditions. We can show whether the compound engine is an economical engine for up hill and down dale, or whether it is simply economical for a level road.

He referred to something that is very interesting to me, and that is, this raising and striking of a blow by the counterbalance. He tells us that at fifty or fifty-five miles an hour there is a slight indentation or flattening of the small wire. I have heard chief engineers of railroads say that that flattening was severe enough to bend a sixty or seventy-pound rail. I think that the experiment should be fully carried out, and I am willing to bear my share of it, just the same as I would if I bought a book to get some information from.

The PRESIDENT—The question is, whether we shall adopt the resolution as presented by Mr. Mitchell. I desire to ask Mr. Mitchell if he wishes to increase the amount to be expended?

Mr. MITCHELL—I am perfectly willing to increase the amount, or to make it not to exceed the amount I named for one year, and then next year to add more to it. I think $5,000 will give ample funds for doing what work we can do this year. But I am perfectly willing to leave the amount out of the resolution entirely and let the Executive Committee collect all they can.

Mr. HENDERSON—I would suggest that the amount be omitted. I spoke to Mr. Forsyth a few moments ago, and he estimates that it will cost about $2,000 to test one engine. It would probably be of very little use to test two engines. We would probably want to test eight or ten. If we only made two tests a year it would be rather slow.

Mr. MITCHELL—Mr. President, I will leave the amount out of my resolution entirely, if that is satisfactory to the seconder. The resolution would then read:

Resolved, That the Committee on Locomotive Tests be instructed to co-operate with the committee from the Mechanical Engineers' Society in a series of comparative shop tests of compound and simple locomotives, to be made on the locomotive testing apparatus of the Purdue University.

Second, That the Executive Committee be instructed to provide funds to pay the necessary expenses connected with such shop tests, and solicit subscriptions for this account from railroad companies and locomotive builders.

The PRESIDENT—What number do you desire that committee shall consist of?

Mr. MITCHELL—I would suggest that the committee that is now on this subject of locomotive tests, which is continued, be instructed to make these tests.

Mr. SETCHEL—Is that the Executive Committee that is named in that resolution?

Mr. MITCHELL—The Executive Committee is only to collect the funds. The Committee on Locomotive Tests makes the tests.

Mr. Mitchell's resolution was carried.

The PRESIDENT—The committee will be appointed later.

The next thing in order is "Malleable Iron Castings."

Secretary SINCLAIR read the following report of the committee on this subject:

MALLEABLE IRON CASTINGS.

Your Committee on Malleable Iron Castings have been instructed to consider to what extent malleable iron castings can be used to take the place of expensive forgings, and now beg to report that they have communicated with all members of the Association, all principal locomotive builders and all manufacturers of malleable iron castings; and, having carefully tabulated and considered the replies received, have reached the conclusion.

that there is no evidence to indicate the probability that malleable iron castings can be generally used as a substitute for expensive forgings. Malleable iron castings, as now used in connection with locomotive construction, are principally either substitutes for gray iron castings or for small and inexpensive forgings. The Committee have not reached a single suggestion that malleable iron can be economically introduced in place of the larger and more expensive forgings which are now used in locomotive construction.

In collecting information on the subject, the Committee have, however, been put in possession of a quite complete list of those detail parts of locomotives which are now commonly or occasionally made in malleable iron; and for the information of members and as an addition to the records of the association, we give herewith a list of such detail parts as are, or may be, made in malleable iron :

BOILER FITTINGS.

Stay-bolt cap nuts, water grate-bar bushings, frame pads, crown-bar washers, spark-hopper fittings, fire-door fittings, gauge-cock drip funnels, handhole bridge, gauge-cock stand, gauge-cock wheel, injector handles, injector drip funnel, smokebox door clamps, smokebox hinges, jacket-band lugs, sandbox nozzles, sand-lever handles, grate-lever latch, grate-lever joint pins, ash-pan damper details, bell clapper, bell-shaft arm, whistle lever, whistle-lever crank, whistle-bowl top, cock handles.

RUNNING GEAR.

Reverse-lever latch handle, throttle-lever latch handle, throttle-lever quadrant, throttle-lever latch, link hanger, balanced-valve strips, driving-boxes, eccentric straps, valve-stem clamps, spring clips, spring saddles, pedestal caps.

CAB FIXTURES.

Door fasteners, arm-rest brackets, ventilator brackets, cab handles, cab hand-rails, corner brackets.

BRAKE GEAR.

Bracket for engineer's valve, dummy coupling, hose clamps, hose connections, brake-shaft bracket, brake-heads, brake-shoe adjuster, brake-lever fulcrum, brake-lever guide, brake-wheel.

MISCELLANEOUS.

Flag-holder sockets, lamp sockets, lamp brackets, feed-hose

couplings, feed-hose clamps, feed connection, bell cranks, goose necks, apron hinges, chafing casting-socket, guide-yoke guard, cylinder-cock rigging, front draw-bar rest, pilot steps, front draw-head, truck center-plates, oil cups.

TENDER DETAILS.

Truss-rod seat, side bearings, buffers, truck column, truck-column guide, washers, center plates, truck pedestal, box lid, hand-rail, spring cap, poling socket, journal-box wedge.

R. H. SOULE,
WM. GARSTANG,
W. H. THOMAS,
C. H. CORY,
W. D. CROSMAN,
Committee.

Mr. LEWIS—I move that the report be received.

The motion was carried.

DISCUSSION ON MALLEABLE IRON CASTINGS.

The PRESIDENT—The question is now before you for discussion.

Mr. HIGGINS—I would like very much to hear from any of the members who have had any experience with malleable iron for driving-boxes.

Mr. MITCHELL—I understand from conversation with some of the committee that that is one of the subjects they are going to take up next year, and at that time they will have a very full discussion on it.

The PRESIDENT—I would like to ask the chairman of the Committee on Subjects to take that subject up next year.

Mr. MACKENZIE—I move that the discussion be closed.

The PRESIDENT—Before putting that motion I would ask if any member has any experience with malleable iron driving-boxes?

There was no response to the president's question, and the motion to close the discussion was put and carried.

The PRESIDENT—We will proceed to the next order of business, "Attachments between Engine and Tender."

The report on this subject was read by Mr. J. Davis Barnett, as follows:

ATTACHMENTS BETWEEN ENGINE AND TENDER, FOOT-STEPS AND HAND-RAILS.

The tenor of the replies to your Committee's circular clearly show that our members think the risk to enginemen is small from tender either mounting or running under engine foot-plate, in fact is "nil" if the chafing-plates and their backing are in

line and the coupling-bar is horizontal, lying close up to casting. In locating the coupling-bar even better practice is to put it in the vertical center of the chafing-plates, so that the bar has to suffer a straight shear before tender can start to mount engine foot-plate.

Therefore, in the matter of coupling, we indorse the correctness and safety of the practice common in America of coupling engine and tender together, provided the chafing-plates have liberal surface, are of equal height, have ample straight backing (if possible in a single casting), and a stout horizontal wrought-iron draw-bar with cottered coupling-pins of large diameter is used. There are a few who believe that there is more risk to men in case of an accident from the tank moving forward on tender-frame, but no suggestions are made to improve the present mode of securing tank, viz.: by using stout lugs well riveted to tank having the lower flange bolted to frame, and solidly securing the floor inside coal space to frame, so that to shift position the tank has either to mount the floor, or, bodily shear the floor off the frame.

Safety couplings should be used to supplement the coupling-bar, and with two exceptions the replies favor stout chain in short links as better than side coupling-bars. If solid side-bars are used one end should have an oval or slotted hole, so that there shall be no tendency to bind when on curves.

The securing of the ends of the safety chains is in many cases of a most flimsy character. The best sent us is from D. S. S. & A. R., both chains being permanently held to the tender beam by double-ended staple bolts of 1½-inch round iron, the loose ends being coupled to the underside of engine draw-casting by two pair of pendent lugs cast on, through which (and through last link of chain) passes a 1¼-inch horizontal cottered bolt. Many replies say 1-inch round iron is strong enough for safety chains, but the D. S. S. & A. R. very properly use four links 6 inches long of 1½-inch round iron.

Chafing-plates are commonly of chilled cast-iron, 30-inch to 40-inch area, although some face with steel plate, and one takes the wear direct on the wrought-iron wedge. No information is given as to relative cost and wear of soft and chilled iron for this service.

There is apparently no uniformity in the shape of chafing

surfaces, some making both surfaces flat, others make one flat and one round, and the P. & R. use both rounded, each to a radius struck from the center of its coupling-pin. This insures contact when the vehicles are either on curve or tangent without that pinching and bending which is responsible for some of the undesirable lengthening of the coupling-bar.

Half of the members replying use a wedge to take up the slack in bar and the wear in chafing-plates, and it is to be inferred from the limited information given that they use a horizontal wedge, requiring for adjustment the labor of separating the engine from the tender and then coupling up again, as no reply gives any experience with patented or other vertical wedges that take up the slack automatically, that is, take it up by gravity. One reports using an eccentric bush on coupling-pin, to vary the length of coupling-bar.

With the single exception before mentioned the wedge is behind one of the chafing-plates, so that no direct wear comes upon the wedge itself.

Apart from use of wedge and eccentric, no other form of taking up wear and slack is mentioned, other than the old-fashioned practice of taking out the coupling-bar and getting it upset by a smith.

No difficulty or increased resistance in backing around a sharp curve has been noticed with any width or shape of chafing surface, if the gangway or platform of tender is properly curved so that it does not foul engine when on sharp curve.

It is so difficult to believe that some such resistance does not exist, that we were at first inclined to indorse the P. & R. plan of rounding both chafing surfaces to curves struck from center of draw-pins, as this results in the coupling-pins being exactly the same distance apart, independent of the relative positions of engine and tender; but one member of this Committee, with special experience in propelling trains tender first around curves, says, if the chafing surfaces are rounded to any short radius the pressure tends to derail the tender or turn the rail over, and always causes excessive wear on the journal collars of the tender axles. He now uses a flat plate on engine, 8 x 20 inches long, and this length is used to prevent tender chafing-face slipping by the ends and locking, as did occur when a shorter flat plate was used. The

tender surface is 8 x 10 inches long, curved to a radius struck from center of forward tender truck. If other conditions made it advisable to curve the engine chafing surface, he would do it to a radius struck from center of rear driving axle.

The L. & N. W. Ry. and the P. R. R. use a spring buffer coupling arrangement on new work, and the N. & W. R. think such a plan has advantages. The main draw-bar like the side couplings has clearance at one end to allow for free play of spring in compression, as well as freedom in curving.

A fair inference from practice permitting so elastic and flexible a connection is, that its users and indorsers do not consider there is any risk to men on foot-plate that justifies a closer interlocking arrangement.

Probably the intention in using a buffer coupling now—as in the early days of the locomotive—is to increase the comfort of the passengers, as well as to lessen sudden shocks on metal, and the strains tending to rack tender frame.

STEPS.

A full third of the replies express a preference for short steps—that is, under 12 inches long; two specify 12 inches, and the remainder run from 16 inches to 24 inches, emphasis in many cases being laid on the necessity for high flanges on three sides, although some few do not use flanges.

As to position horizontally: some say a low step is safe, but the distance of the lowest step above rail varies from one each of 12, 14 and 15 inches, up to the more common height of 20 inches (that is 24 inches above tie level), and there is an evident reluctance to having more than one additional step above the first step, however close to rail the first step be located, or whatever be the height of the other "risers."

It is not evident why the first "riser" (that is, the distance from tie to first step) should so commonly be higher than the second and third "risers," except it be to clear snow or other obstruction at low level. Even any equal division of the total height by two steps into three equal "risers" is not shown on any reply, although that would appear to be a more judicious and safer course for the men than the common practice.

Two advocate adjustable steps (apparently to be altered to suit the personal ideas of each runner). This the Committee

thinks a mistake, believing a permanent fastening at a uniform height on all engines will, all things considered, offer less risk the year round.

But two advocate steps at same level on both engine and tender, although there seems an additional element of safety in such a course. Apparently there is an endeavor to put all the steps on one of the vehicles (either engine or tender) when this is possible.

The majority say that in material for steps, wood and rubber have no appreciable advantages over iron; but few use wood, and one only mentions rubber. Roughened and perforated iron plate is the best practice, for although castings with serrated surface are common, the lighter weight and the freedom with which wrought-iron can in winter be struck with a hammer (thus at once disengaging all ice) gives it the preference. The roughening of surface is usually done with a diamond-pointed chisel by hand.

HAND-RAILS.

A strong preference is expressed for long vertical handles on tender-tanks, with an occasional vote for short handles on cab, although it seems as if every reason given for the use of long handles on tanks will apply with equal force to reasonably long handles on cabs—say within a limit of 24 inches. Long horizontal side handles on tank (to correspond with long side steps) are neither used nor desired.

Opinion as to the use of cross hand-rails (that, is hand-rails at front and back) where engine is equipped with pilot, is very diverse. The nearest approach to a generalization of the answers, is that the engines with pilots should not have hand-rails, except for pushing and suburban, and perhaps for some regular way-freight services, because, however useful to railway servants, they are a temptation inviting other people to steal rides at points where they risk life and limb.

J. DAVIS BARNETT,
G. W. STEVENS,
C. E. SMART,
J. W. HILL, } *Committee.*

DISCUSSION ON ATTACHMENTS BETWEEN ENGINE AND TENDER.

Mr. J. DAVIS BARNETT—I wish to make one or two points of comment on the report itself and perhaps a point of explanation. Perhaps the point

of explanation would come in order first. Some of the committee thought it would be better to tabulate the replies showing how many voted and how the votes went. We were not unanimous on that point, and the report has gone in in the form in which it has just been read; and I would say, in explanation, that but twenty-three replies were received, and one of those was so late that the report was in the secretary's hands when it was received. Therefore, very emphatic as are the statements of the committee, they embody the opinions of only twenty-three members of this association. But the report, it seems to me, reads better in the form in which it has been presented to you, and you will accept it now with that qualifying information. A majority of the replies as received came in the form of blue-prints, and the committee had to analyze and dimension the blue-prints and work up the information in the best way they could from that source. I may say that in the matter of draw-bars, for instance, there is some very bad practice on this continent, if one were to accept the blue-prints as representing the actual shop and road practice. In bent coupling-bars there are cases where the double set put in the bar is put in a distance equal to twice the thickness of the bar, and where no reason could be seen why a gentle curve could not have been used, making that bar stronger for its service without increasing its weight.

There is another case where the bar is set downward almost at an angle of 45°, a very great depth; the sharpest possible corners are shown, and even the hubs on the ends of the bar are not so put on as to lessen that bend. The hubs are so put on as to increase the amount of angle. That has been sent to the committee, as being good practice, which they recommend to this association. There are cases of very light safety couplings, and I noticed in one engine at the Columbian Exposition, a powerful engine at that, where the safety chains are 1⅞ inches in diameter—just one-third the cross-section area of that which the committee recommends. It seems to me, personally, that if it is worth while putting on the safety chains at all, it is worth while putting on something that will do the work on the rare occasions they are called upon to come into play.

May I say, too, that if the blue-prints are to be believed, the hook usually fastened to the tender, securing the free end of the coupling-chains, is, in many cases, shown with the sharpest possible corner where it bends around the wood—a right-angled turn—the most favorable condition for breakage at that point when a sudden pull comes on, and in many cases it is bolted with but a single bolt. It seems to me of no earthly use if you are running and the coupling-bar should break; you might as well have left all such fixings off.

In the matter of steps, I see no reason why steps should be put up so very high, except it be to clear snow and other obstructions, and it seems to me that is a very poor reason to give, so that they might save a dollar a year. I do think the practice exposes men to very great risk in jumping on engines when they are in motion. I think it would be better, even if we did lose an occasional step, that we put that step so low down as to lessen

that risk. It is my own experience in having men round about engines—not engineers and firemen—that it is under those conditions, perhaps, that more limbs are lost in jumping on and off engines than under the circumstances where engineers and firemen jump on and off. Nevertheless, I can see no justification for the additional risk we expose our servants to by putting that step so high up, except saving the expense of the occasional renewal of the step when it is knocked off by some tie or by snow at the side of the track.

This, of course, is not an important subject like that of tests of locomotives and the compound locomotive. But as one of our associate members said, it was the first subject for a long time that did aim at a consideration for the comfort and convenience of the men daily employed on the engine. Bearing this in mind, when walking through the Columbian Exposition, and noticing an engine said to have been designed by men running the engine, I thought I would pay some little attention to these points and see if an engine designed by men exclusively handling engines was any safer at these points than an engine designed by a master mechanic.

I found as soon as I stepped upon the foot-plate that I could just get the top of my nose onto the brake-wheel. The ratchet and pawl to be worked by the foot to hold that brake-staff from slipping back, was 14½ inches above foot-plate level. The depth of the horse-shoe in the tender was the greatest depth in any tender I have seen for several years, there being no slope either at the back or side to throw fuel well forward to the front. The steps were simply secured by a single set screw, by no means the safest form of securing a step; and the hand-rail and foot-steps in the neighborhood of the head lamp, to be used by men when lighting up, were far from being the safest and most convenient that I have seen.

Mr. LEWIS—I wish to take exception to one remark made by Mr. Barnett, and that is as to the importance of this subject as compared with some other subjects that have been presented. He did not seem to consider this subject as important as some others. I differ with the gentleman, because any subject that involves the injury or loss of life of the employés of railroads is a more important subject than the proportions of a locomotive, and I do not believe that too much importance can be placed upon the suggestions of the committee about this, as regards the safety of employés. We can readily correct any defects in the locomotive in other respects, but we never can recall the injury or death of an employé; and I hope that the suggestions that have been thrown out by the committee will be taken by the members, and that they will profit by those suggestions in the line of improving the appliances to the better protection of employés.

Mr. MITCHELL—I wish to say respecting the engine referred to by Mr. Barnett which the engineers built, that I think the parts that he referred to were designed by the builder. The railroad company with which these engineers were connected had nothing whatever to do with the design in any detail, and in talking with some of the committee of the engineers, I inferred from what they said that they only specified the principal parts, like

the size of cylinders, size of boiler, journal, and such details as that. I think these minor details referred to are the designs of the builders.

Mr. GILLIS—I think in justice to the builder it should also be said that, as I understand, the engineers who designed this engine had inspectors to overlook the construction and see that it was done as they desired.

Mr. MACKENZIE—I was very much interested in the remarks made by Mr. Barnett as to the designing of that engine. It would seem to me, that if a committee of engineers were to design an engine, they would look particularly after the parts that they were to handle and which they knew something about, and would let other parts that they knew nothing about, alone. It seems that they lost sight of the fact that they did not know anything about the boiler or cylinder or anything of that kind, and they went to work and designed those parts of the engine, and when they came to the brake-wheel, as Mr. Barnett says, they put it where they could not get to it without a step-ladder. I am surprised to hear of the condition of that engine. I thought it would be a model engine as to brake attachments and all that sort of thing. I did not suppose the boiler and cylinders would amount to anything, but the minor attachments I did suppose would be very fine.

Mr. GILLIS—In regard to the clause in the report, which says "There are few who believe there is more risk to men in the case of an accident from the tank moving forward on tender-frame, but no suggestions are made to improve the present mode of securing tank," I would say that we do believe on the Norfolk & Western that there is danger from that very cause. We know that there are a number of cases where men have been hurt from the tender sliding forward on the frame, and a design has recently been completed to prevent that. Mr. Henderson might give us some information as to that design.

Mr. HENDERSON—In answer to the question, I would say that some time ago I prepared a sketch showing a couple of lugs, such as Mr. Barnett speaks of, extending below the bottom of the tank and secured by strong iron rods to the rear bolster. This was with the wooden frame. We are now getting up a steel frame, and we expect that the bottom of the tank back of the coal space, will have a heavy angle-iron riveted on wide enough to come between the two center channels, and the angle will be 6 x 4, provided with two rows of rivets, and letting this project down below the top of the frame. Then there will be plates of iron across the top of the frame so that this angle will project below it, and it will be almost impossible for the tank to slide up on that frame without ripping the bottom out of the tank. As I say, we have none of these in use yet, but we expect within a few months to have some of them in service.

Mr. H. TANDY—In order to lessen the liability to injure engineers and firemen, we have lately adopted what we think is a unique tender-step. We have abandoned the step usually put on the engine and have made a step out of one casting, which we attach on the front end of the tender-frame. The first riser is about 20 inches in length and placed 15 inches

above the rail level. The second riser is placed midway between the first riser and the tender flooring, and the entire thing is securely bolted to the front end of the channel-frame ; and the bottom riser, I might mention, is carried forward so that it reaches underneath the tail-end of the engine, and we think it is not necessary to put a step on the engine at all, because if you give a man two steps he thinks that is all he has to use, and if you put one on the engine he thinks he has got to use it if it takes the skin off his shin. This step is all in one piece, and, in the event of breakage, can be easily replaced. That is the reason we make it of cast-iron. Because in the winter time you are liable to strike a snow-bank occasionally, and it is cheaper to attach a new casting than it is very often to straighten out the wrought-iron holders. We have, necessarily, to attach those steps on all the engines we send to the World's Fair, in Chicago ; inasmuch as we have not heard any severe criticism in regard to them, we think they are about right.

Mr. McIntosh—I wish to indorse what the last speaker said as to the step on the engine. From an experience, as fireman and engineer, extending over a good many years, it is my opinion that it is entirely unnecessary, and in fact dangerous ; that the tender-step is all that is required ; that a man is much safer in climbing on that alone than he would be in attempting to use a step on the engine and one on the tender.

Mr. Brown—We use steps similar in design to what are described by Mr. Tandy, with the exception that we use boiler iron and put it on 18 inches wide, bolted to the side of the tender frame and let it run down and form the bottom step. We can put a riser on that on the front edge of it if necessary ; or we put a piece of plate on the front beam, which makes it very convenient for the man to jump on. If it is not convenient to use the beam we rivet it on the front edge of the step.

Mr. Gentry—I would like to ask Mr. Brown if he uses a wooden cover over the boiler iron step, where the foot comes in contact with the step.

Mr. Brown—We just rough it up. We had an idea of putting strips of wood on, but we have not found it necessary yet. We rough the step, and the men like it very well.

Mr. Gentry—In reference to leaving the step entirely off the engine, I would say that in designing our last engines we made our steps with the view of mounting and dismounting entirely by way of the tender. But at the same time we have a step which is very firmly attached to the rail of the engine and if such an engine is standing over a pit you can get in handily from the back end. It is not put there with a view of getting up and down, although I suppose they use it sometimes for that purpose. We have found that in leaving the step entirely off it is very difficult to get up and down from the engine, if the tank is away from it. That is the case in almost all engine-houses.

On motion the discussion was closed.

The President—The next subject gentlemen, is Smoke Prevention. Mr. J. N. Barr is chairman of the committee.

Secretary SINCLAIR—Mr. Gentry is a member of the committee. I have no doubt he will read the report.

The PRESIDENT—Let me say that the report was received too late to be printed.

Mr. GENTRY—I am very glad that it has been stated to the members that the report was received too late to be printed. I should like to state for the benefit of myself and other members of the committee that we did not see the report until we got here. A copy of it was sent to me, which reached my office just as I was leaving, and I brought it with me intending to read it on the train. I had a letter from Mr. Barr, the chairman of the committee, regretting that he had not been able to get out a report that would give more information. Speaking for myself, at léast, I felt some hesitation in attaching my signature to this report, on account of the fact stated by our secretary—that whenever subjects have been referred back to committees, and committees continued, we generally get a worse report in the last case than we did in the first. I propose to read Mr. Barr's report to the association, and if they choose to receive it, all right. If not, they can appoint a new committee on the subject. Mr. Barr expressed his regret at not having been able to make it differently, but he was very much crowded at the time.

Mr. GENTRY then read the report, as follows:

SMOKE PREVENTION.

Your Committee appointed to report in the matter of smoke prevention on locomotives begs to submit the following: Smoke prevention means perfect combustion. The matter of perfect combustion has been discussed, and the principles upon which it depends have been thoroughly established long before the existence of this association. Perfect combustion means: 1. That temperature of the firebox must be maintained at a sufficiently high point to insure prompt combination of the carbon of the fuel with oxygen; 2. An adequate supply of oxygen; 3. Proper presentation of the oxygen to the fuel.

It is unnecessary in this report to go further into detail in the matter of combustion, as full information can be readily obtained from well-known books. It may therefore be taken as an established fact that if the temperature of the bed of fuel is maintained at the proper point, and its efficiency not impaired by the addition of an excess of raw and cold fuel, and if the proper amount of oxygen is supplied, that the prevention of smoke will be accomplished.

We find in practice that the ordinary locomotive with deep

firebox, equipped with fire-brick arch and ten 2-inch combustion tubes, three on each side of the box and two on each end, can be operated practically with no smoke while running. It is understood that the locomotive is fired carefully, the fuel being introduced in small quantities so as not to lower the temperature of the incandescent body of fuel. From the results as to smoke, it may be inferred that when a locomotive is in operation the draft occasioned by the exhaust introduces enough oxygen through the grates and combustion tubes to effect perfect combination with the elements of the fuel, and with the high temperature of the brick arch maintains the gases in the firebox in proper condition to secure perfect combustion. This, however, is not the case when the locomotive is at a standstill. At this time, if the body of the ignited fuel is fully incandescent, no smoke will be produced; but if there is any raw fuel, smoke will manifest itself. Again, if the locomotive stands for some time, causing a decrease in the temperature of the material in the firebox below the point at which a proper combination is effected between the oxygen and the elements of the fuel, smoke will be produced when steam is again turned on.

The matter of smoke prevention, therefore, involves the provision of additional means to meet the requirements of locomotives when at rest and when starting into action. Numerous devices have been arranged for this purpose, the essential basis of all consisting in means for injecting air over the surface of the fire, and any of these devices which furnish air in sufficient quantity over the surface of the fire, the temperature of the fire being properly maintained, will prevent the formation of smoke. Devices of this kind have been in use for at least fifty years. The difficulty in the use of such devices occurs when the temperature of the mass of burning fuel becomes too low; in such cases the device will not prevent smoke, and frequently, by assisting in lowering the temperature of the ignited fuel, will rather foster the formation of smoke than prevent it

If the temperature of the firebox begins to fall below the point at which smoke can be prevented, the difficulty may be avoided by turning on the blower and thus increasing the heat of the firebox. The objection to this practice is its tendency to increase the formation of steam in the boiler and consequent blowing-off

at the safety-valves. If the locomotive is to remain at rest for some time the engineer should prepare for it by allowing water to run low in the boiler ; the fireman should prepare for it by seeing that the firebox contains a considerable amount of fuel in a state of full incandescence. If, with the locomotive in this condition, the period of inaction is so long that the temperature of the firebox falls to the point at which smoke is produced, the conditions are such that the engineer can turn on the blower for some time, and at the same time prevent blowing-off by putting the injector in operation. The fireman can also, if necessary, introduce a small quantity of fuel without producing smoke ; and by putting in operation the apparatus for injecting air over the surface of the fire, the formation of smoke can be prevented for quite a length of time, the locomotive, during this time, being maintained in condition for doing full service.

There seems to be an impression that a smoke consumer, or, more properly, a smoke preventer, can be made which will prevent smoke when put in operation irrespective of the conditions mentioned above ; but this is not the case. If, however, the conditions mentioned above as to proper temperature in the firebox is maintained, any of the numerous devices for consuming smoke which introduce a proper quantity of air into the firebox over the surface of the fuel, will be efficient.

J. N. Barr,
F. Wertsheimer,
T. W. Gentry,
Wm. McIntosh,
W. H. Marshall,
Committee.

Discussion on Smoke Prevention.

On motion the report was received.

Mr. Mitchell—I would like to hear Mr. Gentry's objections to the committee's report.

Mr. Gentry—I cannot say that I entirely disagree with the report. I just said to Mr. Marshall, who was on the committee with me, that if it was the pleasure of the association to accept it, we would very cheerfully sign it. We did not feel, in the first place, that we had been treated just right, because we had not been written to by our chairman, our views had not been asked for. We did not receive a circular. If it were not for the secretary's notification, I would not have known that I was on the committee.

I wrote to the chairman, and asked what line he would map out in getting up the report, and I got a pleasant, nice letter from Mr. Barr, only it was too late, with this tissue copy, saying the matter had been overlooked in the rush of business, and that no discourtesy was intended. There are some features of the report that I think hardly necessary. There are some necessary points that are not included. I think that when a chairman is put on a committee in that way, he ought at least to get his colleagues to express themselves before he comes before the Convention with a report. I think we ought to take that stand, and perhaps some day we will turn down some of those chairmen that way.

Mr. McIntosh—I signed the report under the same circumstances as Mr. Gentry describes, and while agreeing with Mr. Barr in the main, I apprehend that in stating that a certain number of 2-inch flues above the fire is beneficial, he is speaking for the practice of his own road especially, for it is my opinion that the number of openings above the fire would largely depend upon the area of grate opening. For instance, a small area of grate opening would call for a larger number of openings above the fire, while a greater number of grate openings would require fewer openings above the fire, or, possibly, none at all.

Mr. Mitchell—We all know that the smoke passing out of the smokestack of the locomotive is unburnt coal to a great extent. Therefore, to get perfect combustion it is necessary to burn that smoke. The smoke devices, as usually made, are a current of air admitted through hollow stay-bolts or flues through the stays of the firebox. The air is admitted, as a rule, by a nozzle being placed outside of these hollow stay-bolts, which, blowing the steam into the firebox draws the air in with it. I had an opportunity, several years ago, to make a test of what is known as the Hutchinson smoke-burning device, which is practically the same thing. The engine was provided with a brick arch, and in making a test of something like two months' duration we found we were burning more coal with the smoke-burning device than we did without it, thereby demonstrating to our satisfaction that in place of burning the smoke and producing more perfect combustion, we burnt more coal and mixed the steam with the smoke, thereby changing the black color. In my judgment, in a perfect smoke-burning device the air admitted must be heated to the same temperature as the gases before admission in order to burn the smoke, and the temperature of the gases, or, in other words, the temperature of the incoming air must be at least 800 degrees to permit the oxygen to mix with the hydro-carbon gases in order to produce that combustion.

With the French furnace, with which I was connected at one time, we had a hollow brick arch. We admitted the air through six or eight 3-inch hollow flues in the front water table, the air passing through the brick arch became heated to the temperature of the arch, and when the air was admitted to the firebox it mingled with the gases coming off the fire and gave us a perfect combustion of the gases, and reduced the black smoke to a very great extent. That device, however, was a failure, for several reasons, the

principal of which being that the arch would not stand up with the intense heat; and again, where the arch would work successfully with good coal, with poor coal the arch would melt right down. Therefore, I think that any smoke-burning device like a hollow tube and jet, of which most of these smoke-burning devices mentioned are composed, do not burn the smoke or produce more perfect combustion.

Mr. W. H. MARSHALL—As a member of the committee, I wish to state that my position is very much that explained by the others. I do not think that in the report there is anything with which the members want to disagree particularly. They think that it might have been a little more complete. I am very much convinced that the best smoke preventer any of us ever saw is a very good fireman. You can put any device on the locomotive that you please, and if the fireman does not attend to business the locomotive will smoke. If you have a good fireman, and the engine is not perfectly designed, he will probably do good work as a smoke preventer. Some use the steam jet to admit air above the fire, and others use hollow tubes with nothing to propel the air in except the vacuum produced in the smoke-box. I think a number of persons have experimented with that arrangement, and pronounced it a failure because they have failed to take into consideration several facts. For instance, if the grate is of a certain area, and the openings and the depth of the fire are a certain figure, then the openings required will aggregate a certain area. If, however, you change, say, the depth of the fire, going, say, one half as deep, why, then, more of the air is going to come in the grate and less will come through those openings. On the other hand, if you very much increase the depth of the fire or change your grate bars so that the area for air admission is very much less, the vacuum in the smoke-box is going to draw air in from any source you can get it from. Consequently a very much larger proportion will go through these tubes. I have known engines that were fitted up with a certain number of tubes, and those engines were practically the same as others on the road working successfully; but perhaps they were on another division, and the coal was different, and the men handled the engine differently, and perhaps those holes were plugged up, or half of them, and perhaps the engine steamed better.

There is another thing in connection with grates that ought to receive attention. On a number of roads it has been found that a grate pattern which was all right at one time, as far as air spaces were concerned, had gradually thickened up, because the fingers broke or the bars failed in some way, and without very much attention being attached to the subject the air spaces were very much reduced, and I have no doubt but that there are many of these grate-bars to-day giving very much less air space through them than the master mechanic thinks. Regarding hot air, the necessity for heating air to be mingled with the gases above the fire, I am of the opinion that most devices that attempt that are impracticable, and it does not seem to me necessary to heat the air. There is a certain amount of air that can be admitted above a fire, and the temperature of the firebox is

such that it will be heated and will mingle successfully with the gases and those gases will be burnt. If you admit too much, the gas does not combine with the air, simply because the temperature is lower. Therefore, if you will not attempt to admit all the theoretical quantity of air, all air that goes into the firebox will be used in combustion and not in simply reducing the temperature of the box. If, on the other hand, you struggle for too great a perfection you will probably get in more air than can be successfully combined, and your engine will drop off in efficiency instead of the combustion being improved.

Mr. LEEDS—I was at Dunkirk yesterday, and among other things that I took note of, and purposed to try, was what I considered a first-class smoke-consumer, and that was nothing more nor less than a grate-bar which struck me as being just about correct. I do not think that the introduction of cold air above your fire indiscriminately, or even under such control as we are able to give it—inasmuch as we do not handle it ourselves—is beneficial. I think a great deal more of the gases are condensed before they are converted into smoke than there are consumed. In the first place, I do not think that you can, by any possibility, receive benefit from any greater amount of air, introduced in any other way, than what can become heated to the degree of ignition. Several years ago, we tried the introduction of tubes from the back end of the firebox through two 4-inch openings on each side of the door just below this pipe, passing up below the arch of the door and down on each side of the firebox and under the brick arch. Those pipes were drilled full of holes of about $\frac{3}{16}$ths, and of course, the pipe being red hot all the while, the air that passed into it was heated to a great extent before passing over the fire, and decidedly it came the nearest to being a smoke-consumer of anything that I ever saw. We ran it for several months, burned out a great many sets of pipes during the time, and never saved a pound of coal that we could any of us find. I had a fireman who would fire as he was told, and took a great deal of interest in it, and he said that if he would allow the same amount of air to pass through his fire properly and ignite at the surface of the fire with his gases, that he could produce the same results in every way; and I am happy to say that he demonstrated it in about four years that he fired for me, and to-day he is as good an engineer as there is in the country, from the very fact that he gave as much interest to his other business as he did to giving the proper amount of air through his fire. I think the proper way is to fire light enough to just introduce the proper amount of air and get it heated to the igniting point before going into your flue.

Secretary SINCLAIR—The railroads in this country are going through the same requirements and the same necessities in regard to smoke consumption that the leading railroads in Europe passed through about thirty years ago. At that time there was a movement by municipal bodies to prevent railroad companies inflicting the nuisance of smoke upon the country and upon cities. It was carried on so vigorously that the question was either to burn fuel that produced no smoke or to prevent smoke. It was

no idle ordinance or law that was passed. The law was enforced very strictly. The consequence was that railroad companies had to do their best to consume the smoke, or prevent it, or burn coke. Coke was so much more expensive than coal that coal-burning became general, and patentees had made great fortunes in supplying railroad companies with the devices necessary for preventing smoke. Within the last few years municipalities in this country have been stirring up excitement against the usage of smoke, and railroad companies are compelled to listen to them. The effect of this is that our patentees are reproducing the patents of thirty years ago, and, I have no doubt, making a golden harvest from them.

I paid a great deal of attention to the devices for smoke consumption, and I can see nothing now offered to railroad companies that was not in use thirty or forty years ago. After a great deal of experiment and experience with complicated smoke-preventing devices, the railroad companies in Europe dropped down to a few simple arrangements, and that is the common practice to-day—the brick arch and a method of admitting air above the fire. That is considered the best smoke-preventing combination there is—in combination with a good fireman. In no case can the fireman be ignored. I came on the scene shortly after the excitement of smoke prevention in England began. I came on as a fireman, and soon learned that a fireman's life was made very unhappy by those who were after the fellows who raised smoke. It did not matter whether you had a good smoke-preventer or not; you had to prevent smoke, or be summoned to appear before a magistrate. You did not have to go before your superintendent; he did not trouble himself much about that. A constable would come around, and let you understand that you had to have an interview with a magistrate in a day or two if you were raising smoke. Consequently, we were all very active in keeping ourselves out of trouble. At the same time, we were working on the premium system of fuel. We were allowed a certain quantity of fuel for the engine, and whatever we saved we received a premium for it. We were trying to keep out of trouble by preventing smoke, but soon found that the prevention of smoke and the saving of fuel did not agree. If you prevented smoke, you burned more coal. I never knew one case in the whole of the British Isles where this did not follow.

All smoke-preventing patentees offer you their devices on the ground that they save fuel. I have never seen a case yet but that smoke prevention, in a practical way, used up more fuel. You may prevent smoke in laboratory experiments, where you can regulate the supply precisely to suit the demands, and get more heat out of your coal thereby, but if you have to supply your air through the channels necessary to supply the locomotive or a stationary engine boiler, you will use so much air that the tendency is to cool the gases, and on that account you waste fuel. It is well known by those who use smoke-preventing devices on stationary engines, as well as on locomotives, that there is no saving of fuel from it, but it is quite the reverse. At the same time skillful firing, and furnaces well arranged, will keep down the nuisance and prevent trouble with municipal authorities,

and that is the line, as I look upon it, that railroad companies have to follow now.

Mr. McIntosh—The preceding speaker and other gentlemen have laid great stress on the importance of good firemen. I agree with them in every particular. But the best efforts of a good fireman may be rendered inoperative by a careless engineer. It is my opinion that co-operation on the part of the engineer and fireman is necessary to produce these results.

Mr. William Smith—We have got about two hundred engines now with smoke-burning devices of one kind or another—we keep them more from necessity than choice—very largely on the jet principle order. But the best device that I have tried for reducing smoke in general—although it is not satisfactory around cities—is this: We have got a shield about 18 inches long. That is placed inside the firebox just over the furnace door. You run a brick arch, and the brick arch and shield are about 18 inches apart. The furnace door is as far up as you can get it. We have a slot cut out about 1¾ inches deep. Then we have a little damper there, and we run with the damper up, and in firing we put the damper in. The air has to pass down this shield, and comes into the fire between the brick arch and the shield. The air, in passing below this shield, gets heated up pretty hot, and the only trouble we find is the burning out of this shield. They will last one to two months; some will last three months. We turn up a flange on this shield about 2½ or 3 inches. But if that shield could be made to stand, it seems to me it is about the best smoke-preventing device that I know of—that is, for road service and the comfort of passengers.

Mr. McIntosh—All our engines operated in Chicago are equipped with the smoke-preventer known as the Barnes device. The special feature of this is the heating of the air before it is injected into the box; another is that it is practically noiseless. We went into the matter very carefully, and considered this about the best that was in the market. An engine equipped with the brick arch and circulating tubes will not smoke to any great extent, that is to say, we can meet the requirements of the corporations if the engineer and fireman are alive to their duties. Following in this line I have adopted a plan that may be of benefit to those that have to operate engines in Chicago or such places. I have adopted the practice of requiring the engineer to answer the question, Yes or No, on his time slips which he makes out daily, whether he violated the smoke ordinance. Of course, they know what constitutes a violation—during that trip or in the time covered by the slip. I am pleased to say that we have never been called into the courts as yet; that is the only check that you can have against the inspectors who are watching you. If an engineer is called into the courts in three weeks or a month after the violation is alleged to have occurred, the chances are that he will remember nothing and is of no value to you as a witness. We take his time slip, which bears his signature, and hold him entirely responsible. If the engineer should report a violation, we immediately get after it and find out the cause, and in that way we get onto many little defects that we would not otherwise, until the inspectors caught us.

Mr. MITCHELL—I would like to ask Mr. Smith and Mr. McIntosh if by their smoke-burning devices they have effected any saving in coal?

Mr. SMITH—All the smoke-burning devices I have tried have been a waste in fuel with the exception of this one. I have got so tired of hearing about the saving of fuel that I have never made any experiments upon that point with this device, but the firemen in general tell me it is a saving. I know it is a saving on the flues and I know there are a number of men who beg to have it and would not be without it. If there are any of the members of this association who would like blue-prints of it I will send it to them.

The PRESIDENT—Gentlemen, the noon-hour having arrived, the discussion of special subjects is in order. If you desire to continue this discussion after the noon-hour, that can be done. If not, a motion to close it will be in order.

On motion the discussion was closed.

DISCUSSION ON WASHING OUT BOILERS.

The PRESIDENT—We have here an important subject for the noon-hour discussion. I wish you would give it some attention, gentlemen.

Secretary SINCLAIR (reading)—"What is the Best Method of Handling Locomotive Boilers when Washing Out is Required and the Proper Method to be Pursued in the Examination of Stay-bolts?"—handed up by Mr. John Mackenzie.

Mr. MACKENZIE—This is a matter that is interesting us a great deal upon our line, for the reason, first, that we have to run the engines very hard, and the time for washing out is limited. We have been trying different methods of washing out and of testing stay-bolts. We came to the conclusion that the proper time to test stay-bolts is immediately after the water has been blown from the boiler, while the temperature is high and while the steam is left in the boiler. Our method is to blow the water from the boiler out through the blow-off cock; then close the blow-off cock and run the engine into the roundhouse and allow the engine to stand there until an examination is made of the stay-bolts. Then turn the blow-cock and let the steam and water pass out gradually. We allow one hour after the water leaves the boiler before we begin washing out. So far as we have been able to determine we think it is a pretty good plan.

Mr. GENTRY—I would like to get the views of some of the members who have yard masters and train-dispatchers after them for engines. We are limited in power and are very much pressed, and of course we have to stop to wash our boilers. It is a right that we reserve. We do not pay any attention to these people who are hammering at us to get them. But we have that difficulty to contend with, and if there are any methods of successfully dealing with this matter we want to get at them. If I can get any information I would like to have it, and afterwards I will try to tell you how we undertake to do it.

Mr. McINTOSH—In regard to stay-bolts, my opinion is that the best

arrangement for detecting broken stay-bolts is to drill those that are most liable to break—drill the outer ends, or use a hollow bolt. In testing, there is no question but you can determine better the condition of the bolts under steam pressure than you can otherwise.

As regards washing out boilers, under the conditions mentioned by Mr. Mackenzie and Mr. Gentry, it is my experience that this can best be accomplished by filling the boiler. In the first place, blow off the steam and then fill the boiler from the dome or blow-off cock, full of water. When this is accomplished open the blow-off cock or handhole plate sufficiently to allow the same quantity of water to run out that is going in. In this manner you cool your boiler off uniformly. All portions of it will have a like temperature. Continue this process until you have reduced the temperature to such a point that you can place your hand on the boiler, or nearly to that point, and then let the water all out and proceed to wash out. You can reduce the temperature in this manner in from thirty to forty-five minutes. and the washing out can be accomplished very quickly afterwards. We do the washing out with hot water, and also fill the boiler again with hot water.

Mr. W. C. Arp—The practice at the Dennison shops in regard to washing out is to attach a hose to the feed-pipe, and then allow the water, the hot water or steam, to pass out through the blow-off cock, holding the water at the third or fourth gauge-cock, as the case may be, until the boiler becomes cold enough to lay your hand on. Then we let the water out, and proceed with our washing out. It takes us an hour and thirty minutes to an hour and forty-five minutes.

In answer to the question that Mr. Gentry put, I would say that when we get an engine in the roundhouse, we consider that the dispatcher has nothing to do with it until we say it is ready. That is the way we do. He can shout until he gets tired; he does not get the engine until we say that it is ready and he can have it.

Mr. Leeds—I would say that my practice for several years, and my instructions since I have given up the direct care of locomotives, correspond exactly with what this gentleman has said. I found that by filling through the injector throttles we could change the temperature of the water very fast, and bring the boiler down to its lowest temperature without any injury to it. But I always did insist, in filling the boiler, that the throttles should be closed, for the very reason that our dry-pipe running into the dome, if it is over the crown-sheet, introduces the water directly on to the crown-sheet. and if there was any difference in the temperature of the water and of the crown-sheet it caused a contraction there that I did not care about having, and if the dome was forward of the wagon top, as it is in the Belpaire boiler, then it was spreading itself over the flues a great deal worse than it would through the jets. That is the only difference I have made in my practice from what this gentleman has just said. I have never had any trouble with weak flues, cracked fireboxes or anything of the kind, and it seems to me I have handled engines very expeditiously in that way.

Mr. Arp—Some of the members may think that it would take a long time to get the steam on the engine with cold water; but we have a steam pipe running through our roundhouse to which we have an attachment that we can attach to the boiler, and we can get steam on the engine with cold water, so that we can move her out of the roundhouse in twenty minutes after being washed out.

Mr. Leeds—I have always taken exception to that way of firing up an engine. I would a great deal rather heat the water before it is put into the boiler, and that is the reason I do not like to introduce hot water, even on to a cold crown-sheet or to a cold flue. But I do think that the practice of forcing the fire in a boiler that perhaps is up to 180 or 200 from the hot water you have put into it is injurious, from the very fact that you are transmitting your heat through your flues all over these surfaces and in direct contact with the fire, and trying to transmit that heat to the shell of your boiler through your water, and I think the expansion of your flues is injurious to your boiler under a forced draft. I would rather take that same amount of steam and introduce it directly into the boiler, which I do.

Mr. Gentry—We do not have any necessity for using cold water at all, because we use a very heavy steam boiler washer, and our method is very much like Mr. Mackenzie's and Mr. Leeds'. In fact, I find it to be a very common one, and prevails, I suppose, in every well regulated engine-house, or should. Our practice is in hurrying our engines out—our pits are all culverted to a very large culvert, and the blow-cocks of the engines are all fitted with the standard screw threads. We simply couple on a pipe rather larger than the blow-cock. We immediately blow the steam out, and after turning on the stop-cock a little bit our boiler washers connect it up with the feed-pipe. We immediately commence to fill the engine with water of probably a little lower temperature than that which we are letting out, and, as I have explained before, our water is of such a nature that we have very little scale to contend with. After the boiler has been reduced so that the temperature is down beyond the drying point of scale and silt we simply run all the water out there and finish the washing of the boiler with this hot water. After washing out with this stream of hot water we start our fire and, of course, put on our steam blower with the pressure gotten up very soon, although it takes us about twenty-five or thirty minutes to get the full head of steam on one of our engines. We do not use any cold water about washing a boiler at all or about filling a boiler. We often use this same boiler washing for testing our stay-bolts; that is, we use the water pressure. We find, in going around, that nearly everybody is equipped with about just the same devices as we are for blowing up a cold engine. There is one little thing we have that is not generally adopted in engine-houses, and that is we simply extend our steam-pipe that we use in filling the engines up back about as far as the air-pump is situated on our engines and there we have a piece of steam-hose, and our air-brake inspector has the advantage of testing everything while the engine has steam off, if he wants to. We have had trouble with some passenger engines once or

twice through not being able to make a proper test until we had steam. We found some defect just about when the engine ought to be ready to take the train out and we had to change the pump. The members will find this arrangement of running their air-pumps is a very good one.

Discussion on Inspection of Stay-Bolts.

The President—The question of the examination of stay-bolts has not been touched upon.

Mr. Mackenzie—I was just going to call attention to that, and particularly the method of blowing the water from the boiler. We blow the water entirely from the boiler, and soon after the engine arrives at its terminal point it is brought to the place where it is supposed to be blown off. We try to get as much steam on the boiler as possible before we clean the fire, and then blow the water until it is all out; then close the blow-off cock and run the engine into the roundhouse and let her stand there at least one hour. We find from that practice that the vaporizing of the steam that is in the boiler, and the gradual cooling off, softens the mud on the crown-sheet, and our boiler-washers tell me that very much less scale comes from the boiler than was formerly the case. Another thing about testing stay-bolts: we think that with the water out of the boiler and the boiler being warm, any expansion at all between the shell of the boiler and the firebox would, naturally, bring the stay-bolts apart, and if there is a particle of space between there the sound would be brought to you. If the water is there you cannot detect the sound. That is what we claim, and for that reason we follow the practice of testing the stay-bolts without water in them, but with steam in the boiler.

Mr. Brown—Our method of trying stay-bolts is something similar to what is described by the gentleman. We would rather test the stay-bolts without water, and we would like to do it as soon as possible after the water has gone out, and we do it every time that the fire is out, whether it is once a week or once in two weeks, or when we wash it out, once a month. Every time the fire is out a man goes in and sounds the stay-bolts, and if he finds any broken he will report it. We then take the jacket off and sound, by holding a hammer and hammering, the inside of it; and we do another thing, when they are broken we generally get outside the broken bolts. If the engine will run until her time to be washed out, which we consider is once a month or once in five weeks, we do that. Meanwhile if anything happens—if flues or steam-pipes give out—a man goes in and sounds her.

Mr. Gent[illegible]—Does Mr. Brown test his stay-bolts without any pressure on the boiler?

Mr. Brown—Yes, sir. The man goes in immediately after the water has gone out. He does not wait until she cools off. It is very seldom that he misses any. I do not know that a bolt is ever broken, but what we find it when we put the hammer on. As I say if it is one stay-bolt here or there that we [illegible] we might do so, but if there is a single

of them, why out they come, and we take the jacket off and sound the whole of them then.

Mr. Gentry—I believe where the best practice prevails and the most success is obtained in locating broken stay-bolts is where they test the flues with pressure on the boiler. We do that. We have an idea that by expanding the sheet with pressure, if there is a broken bolt we will get the sheet forced sufficiently away from the contact with the bolt to locate it better even than with the hammer test itself. It is our practice to test our bolts as often as we can. Mr. Brown says that they wash their boilers about once in a month or five weeks. We wash our boilers every round trip. We never think of allowing a consolidation engine or a ten-wheel engine to go longer than that. Our freight engines run from Richmond to Atlanta, Georgia, 560 miles in one direction, and back. That is a round trip with those engines. We of course wash the engines every time they make a round trip. The passenger engines' run is shorter, and we wash them about every two trips. That is one reason why we have made such a preparation for washing boilers, and I think our practice will probably compare very favorably with that of almost anybody else, because we have a large amount of boiler washing to do, and it has paid us to go to a great deal of trouble.

Mr. Mackenzie says that we are ignoring the stay-bolt business. I would like to know if it is not rather more general practice to test bolts with a sufficient pressure on the boiler to help in locating? We have got an idea in our shop, that if there is a broken stay-bolt, and a contraction happens to take place, the parts are very close together, while if we have a pressure there we force them apart a little bit.

The President—Mr. Barnett, will you address the Convention on this subject?

Mr. Barnett—I doubt if I have any contribution of any interest to make to this discussion. We wash out with hot water. I suppose almost all of you are doing that to-day. We run the water out of the boiler into a hot well, seeing that the washing out is done with a pump and not by a boiler-washer. The testing of the stay-bolts is done when the engine is cold. I certainly feel like suggesting to our people that they see what value there is in testing them while the boiler is warm. I have not tried it in my own practice, and therefore cannot give an opinion as to its value. Theoretically I should think that that was the better practice.

Mr. Mitchell—There is a great deal of difference, I find, in our practice in locating broken stay-bolts. We had occasion to make a test the other day. We had to remove a firebox from a locomotive. That locomotive was sent to the shop and a sketch was made of every stay-bolt in the boiler and the exact location. Then the inspectors from that territory covering all the shops were sent to this point and they were asked to sound those stay-bolts, and give the man who had charge of the drawing every broken stay-bolt in the boiler. After all the inspectors had sounded the stay-bolts from that boiler and had located every broken stay-bolt, the fire-

box was cut out and every broken stay-bolt exactly located and a correct drawing made and a comparison made between each individual inspection and the accurate statement showing the exact location of the broken stay-bolts. We found a great variation in the broken stay-bolts discovered by the inspectors. We also found that all the inspectors, I think, without exception, called some sound stay-bolts broken. It showed the need of educating our inspectors to be more careful in this work. That was done with the boiler cold.

Mr. GENTRY—I would like to ask Mr. Mitchell if the inspectors marked any broken stay-bolts sound?

Mr. MITCHELL—Yes, sir. Every inspector marked some broken ones sound.

Mr. LEWIS—I was just going to mention the matter when Mr. Mitchell got up. The question both of boiler washing and stay-bolt inspection is a very important one, and there are some things that have been mentioned here that I do not agree with. Mr. Mackenzie was of the opinion that blowing the water out of the boiler and leaving a portion of steam on the boiler had a tendency to soften up the scale. My practice has convinced me that filling the boiler with water while it yet has steam on and cooling it quite gradually, as described by some of the gentlemen, that less scale is deposited in that way than it is where you blow the water out of the boiler entirely and allow the boiler to remain empty. We all know that a certain amount of scum and sediment that is in suspension in the water, when the water is blown from the boiler, gradually deposits itself on the flues and sheets as the water recedes from the boiler. If the boiler is hot that will bake on to the flues and inside of the boiler and adhere to it, while if the water is blown from the boiler while water is being forced in, a great deal of this sediment will pass off with the water and will not deposit itself on the iron. We will get a more uniform contraction in that way. We start off with say 50 or 60 pounds of steam on the engine. We have a steam pump with 80 to 100 pounds cumulative pressure, and we can force the water into the boiler until it is absolutely cool, and the cooling of all parts of the boiler takes place uniformly. I think it is usually the best practice to cool an engine in that way, and when once cooled I do not see that it makes much difference whether the engine is washed with warm water or cold water.

So far as the injurious effect of the admission of cold or hot water is concerned, of course it is more desirable to have warm water; but in nearly all the appliances I have seen in roundhouses, where they claim to wash with warm water, it does not amount to anything. In a roundhouse of one of the large Western roads, where they had appliances for washing with warm water, there were hot-water pipes running around the roundhouse. I remarked to the master mechanic that I noticed he was washing with warm water. He said, "Yes, we do that here." I put my hand in the water that they were washing it with, and it was far from warm. It was cold enough to drink. I called his attention to that fact and he said, "Of course

we can't keep that water to a proper temperature always. We aim to do it, but we do not do it." I notice that is the case with most plants where they claim to wash with warm water.

In the matter of stay-bolt inspection, of course we require a daily inspection for broken stay-bolts, but we also have a monthly inspection, and we have a blank prepared for the purpose, on which the men are required to report this monthly inspection, giving in their judgment the number of broken stay-bolts that they found at the time by the monthly inspection. I had two engines at an outlying point where the man who was supposed to do this work was not very successful, and he reported one of these engines as being examined in the regular monthly examination, and reported only five stay-bolts broken at the time that he made this examination. Two days after this report was made I had occasion to bring the engine to the shop, and an examination was made by our regular inspector, and we found over two hundred broken stay-bolts in that boiler. That showed that we are dependent upon the judgment and skill of men who are not always competent to judge of these questions, and as Mr. Mitchell explained where he collected all the inspectors within a certain range on his road and conducted this test, there is a great variation in the judgment of the men as to the bolts that are broken and the bolts that are not broken. I think that the move made by Mr. Mitchell was a very good one, and if it were practiced by all roads it would be a great benefit. It would educate the men up to a better knowledge and a better judgment of the condition of broken stay-bolts.

Mr. GILLIS—One of our superintendents of motive power, Mr. Sanderson, has just made extensive experiments in regard to testing stay-bolts, spending two or three months altogether, making a study of the matter with inspectors and in every way he could. The conclusion he reached would substantiate what Mr. Mackenzie said, I think, that the test with a slight steam pressure for the stay-bolts is the best test. We had some very old inspectors who were considered very expert, but when they tried to test the stays with the water in the boilers they did not seem to be very expert, as they found hardly any of the broken stay-bolts that were broken, but nearly all of them were able to detect a large majority of the bolts when the boiler was tested with a slight pressure in. I think that we can combine to good advantage the washing out and the testing of stay-bolts. I believe that a boiler can be washed out more quickly and fired up in the method suggested by Mr. Gentry, but I think the safety of the boiler of far more importance than the quickness of washing out.

Mr. LEEDS—I boiled my men by putting them in the boiler until my sense of humanity caused me to discontinue the practice. I found that I was finding more stay-bolts broken when the engine came into the shop than there were under the old system of the water-pressure. I am now applying the principle of compounding to my inspection. I pump into one reservoir, and then take the air from that with another pump and pass it over into another chamber. I double the power of my pump. In other

words, I can pump up to 120 or 130 pounds pressure in my second reservoir with an ordinary pump. I propose to apply the air-pressure to all boilers where we can give them a thorough inspection, and after trial I find that they discover more stay-bolts in that way than they do with the water-pressure and decidedly more than they did with the steam-pressure where they were liable to blister themselves all up.

But the principal thing I wanted to say is, that for years, in fact on the entire system, before I took it as a system, there had been a practice in vogue that I think is a good one, and that is, we stop all our lag above the top row of stay-bolts on both sides the entire length of the outside of the firebox, and at the base of that we rivet on a strip of iron with small quarter-inch studs, and from that down we have a sheet continuing the jacket from running-board, both into the cab and outside, and by taking off a few nuts on each side we can take these sheets off. We can hold on the dolly-bar at any time without moving any of the rest of our jacket.

Mr. GENTRY—It seems to be the general impression that it is an advantage to have the pressure in the boiler when you are going to test the stay-bolts. Am I to infer from what Mr. Gillis has said, that there is a difference in the density of the sound when the boiler is under pressure, and when it is not under pressure?

Mr. GILLIS—The idea is, that the water forms a connection between the two broken parts and makes a difference in sound.

Mr. GENTRY—Then I do not see why Mr. Leeds' idea of using air is not as good as using steam. We have tried this system ever since, and we have very low fireboxes with long arches and the engines are long, and they never get cool enough, hardly, for a man to go in there and remain there long enough with his wits about him to make a sufficient test. We did not consider that it was humane, either, to cause a man to go in there under those circumstances. In fact, we had a man who died of pneumonia, which was superinduced by what he had to do—a matter about which I felt somewhat conscience stricken. We commenced to use warm water. Our boiler is never so warm but that you can put your hand against it. In fact, we do not let our boiler get cold at all, if we can help it—at least, those in regular service. They never get dead cold, unless we have some big work on them. We had an excellent opportunity there to demonstrate what Mr. Lewis called our attention to about blowing the water out of our engine with quite a high pressure of steam on. Our water is mostly pumped from rivers, and it is nearly all muddy, and we have cut sections from tubes that have been removed and we have cut little sections from boiler plates that have been removed. I believe with a microscope a man could detect the number of times the boiler had been allowed to dry off; the little layers are so separate and distinct, and they often show difference in color where the engine has been in different localities and using different water.

Mr. MCINTOSH—I failed to hear any of the members speak of experience with drilled stay-bolt holes. It is my impression that in the ordinary

methods of testing the bolts we are depending entirely too much on the skill of the inspector. One inspector may be well qualified in that respect, and another quite indifferently qualified, and the results obtained would, of course, correspond with the skill of the respective inspectors. I know from a long experience with the custom of drilling bolts that, if followed up, it will produce more satisfactory results. You would know for certain whether your bolt was broken or not if you drilled, and you do not know under any other circumstances. I had occasion to drill stay-bolts in a firebox that had been tested by skillful inspectors, with the result of finding, I may safely say, a dozen of bolts broken on each side that could not be detected by the best inspector we had. I think if we take into consideration the amount of time that is wasted in testing these engines hot and under different conditions, if the time was so applied toward drilling the bolts, we would have more satisfactory results.

Mr. PURVES—Our method of washing boilers is similar to that followed by Mr. Leeds and some of the other members, and, so far, I am happy to say that we have not a stay-bolt on our line but what is drilled. Our method of inspection is very simple, indeed. We know a stay-bolt leaks and we take it out; that is all there is to it. We have no hammering, no dolly-bar holding, no water pressure, no steam pressure, only air pressure. Our jackets are fastened similarly to the practice followed by Mr. Leeds, and every three months the jackets are removed and every stay-bolt exposed. Of course, I do not mean to say that we remove stay-bolts only once in three months. Our locomotive inspector in the engine-house during his inspection, if he sees a little crust forming over the end of the bolt, he reports it to our foreman boiler maker. The engine then is fired up, perhaps, ready to go out. Our foreman boiler inspector looks at it, locates it, and the engine is ordered to come in and fire-dump the following trip. The stay-bolt is removed. This, understand, is with reference to the stay-bolts that show below the jacket. When the three months comes around, the jackets are removed, and if there is any indication of a crusting at the end of the stay-bolt that stay-bolt is also removed. We feel very safe in regard to the condition of our stay-bolts. If the inspector detects a stay-bolt with water oozing from the hole, we conclude that the stay-bolt is broken. The engine is not allowed to leave the roundhouse for the trip. She is immediately taken to the dump-pit, the steam and water are blown out, and that stay-bolt is removed. So we can go home and rest every night quietly and comfortably, knowing that we have not a broken stay-bolt on the line.

Mr. GENTRY—Mr. President, that sounds mighty nice. We have got engines on portions of our road that run into our shops at Manchester that were built about twenty years ago. Some of them have got their original fireboxes, and we have never gone to the expense and trouble of drilling all those stay-bolts out. For the last few years we have not had any engines built that have not drilled stay-bolts or hollow stay-bolts. But we have got about thirty engines to take care of, about which I hardly ever go to bed at night without feeling some uneasiness. That is the kind of experi-

ence that most men are having and suffering. It is not where we have these nice kid-glove arrangements. We have a certain amount of that, and are getting more of it.

Mr. Forsyth—Our practice corresponds with what has just been described in drilling stay-bolts on the outside. We have entirely abandoned the regular inspection of the stay-bolts on engines in service, but a special examination of stay-bolts of locomotives in service must be made once a month. Inspectors are required to use special care in seeing that the holes in stay-bolts are thoroughly cleaned. During the inspection there must not be less than thirty pounds steam pressure on the boiler. A locomotive having one or more stay bolts broken in the top row, or two or more in any other row, must not remain in service. The holes in the ends of all stay-bolts must be thoroughly cleaned out when engine is in shop for repairs. Each master mechanic must keep a record of boilers tested and inspected, giving the age of the boiler, the date tested, date inspected, the name of the inspector and remarks on the general condition of the boiler.

The President—It is now approaching the end of the noon hour and we will now have to proceed with the regular order of business. The next thing in order is the report of the Committee on Tender-Frames.

Mr. R. C. Blackall read the following report:

Tender-Frames.

Your Committee, appointed at the last Annual Convention held at Saratoga, to report on the best form of tender and truck-frames of wood and iron, respectfully submit subjoined report:

The following interrogatory circular was issued:

1st. What is your preference, iron or wood, for tender-frames?

2d. Have you adopted a standard tender-frame of wood or iron?

3d. With iron tender-frames, how long have they been in service, and have you experienced any difficulty with rivets becoming loose?

4th. What is your preference for material in tanks—iron or steel?

5th. What is the capacity in gallons of your standard tank?

6th. Please give a description or blue-print of your standard tender-truck, and state whether you use center and side bearings on both trucks?

7th. What is the size of your standard axle and journal for tender-trucks?

8th. What material do you prefer for axles, and what are your reasons for the preference?

Any further information pertinent to these questions is respectfully solicited.

To the circular we have received thirty-nine replies, representing 62,868 miles of railroad and 12,526 locomotives. We do not think it advisable to take time and space to give each answer in detail, but will condense them as much as possible.

To question No. 1, eighteen have preference for wood, eighteen for iron, and three have no choice. The eighteen preferring wood represent 35,398 miles and 5,738 locomotives. The eighteen preferring iron represent 22,023 miles and 5,571 locomotives. The three having no choice represent 5,447 miles and 1,217 locomotives.

Of the number preferring wood, seven have had no experience with iron, three have used iron and had no serious difficulty, two say they are very expensive to maintain, one does not like them, and one thinks a good iron frame can be made. The following roads have adopted it as a standard, and give us cost of construction, as follows:

Del., Lack. & Western, Scranton, Pa	$225 00
Baltimore & Ohio	190 50
Union Pacific R.R	185 00
Pennsylvania R.R	160 00
Delaware & Hudson	150 00
Wisconsin Central	145 00
Canadian Pacific	115 00
Illinois Central	101 77
Chicago, Rock Island & Pacific	92 00
Pennsylvania & Northwestern	89 00
Ohio & Mississippi	68 00
Philadelphia, Wilmington & Baltimore	32 33

Of the eighteen who prefer iron tender-frames, thirteen have adopted it as a standard, one is using wood, and four do not answer the question. The cost of construction is given by only four, and is as follows:

New York, Lake Erie & Western	$365 00
Boston & Albany	280 00
Lake Shore & Michigan Southern	204 52
Del., Lack. & Western, Kingsland, N. J	200 00

In answer to question No. 3, one gives length of service as 16 years, four as 12 years, two as 11 years, one as 10 years, one as 8 years, three as 7 years and two as 6 years. Five say: "Have had no trouble whatever with loose rivets." One says:

"Seven years and never had a loose rivet." Another says: "Been in use 11 years and to-day are as good as new." Two say: "No difficulty whatever when riveting is properly done." Another says: "No serious trouble with loose rivets." Four say: "Some trouble with loose rivets, but not to any extent." Five do not answer the question.

In answer to question No. 4, twenty-seven use steel and two use iron for tanks, with capacity ranging from 3,000 to 4,000 gallons. Six do not answer the question. The Chicago, Milwaukee & St. Paul, and the Delaware & Hudson report having trouble with steel for tanks, as it deteriorates more rapidly in coal space than does iron.

Thirteen are using steel and seventeen are using iron for tender-axles. Nine do not make any reply. Twenty-four are using a diamond truck. Four are using the square iron truck. One is using the Fox pressed-steel truck, and ten do not answer the question.

Twenty are using center bearings on forward truck, and center and side bearings on rear truck. Nine are using center and side bearings on both trucks. Three are using only side bearings on both trucks. Two are using only center bearings on both trucks. Two are using only center bearings on forward and side bearings on rear trucks.

Regarding the preference of material for tender-frames the "honors are about even," and as there is a difference of opinion with the Committee, we have deemed it advisable to recommend both the wood and iron tender-frame to the Convention for their consideration, and respectfully call your attention to blue-prints herewith presented. We desire, however, to make favorable mention of the standard iron frame of the New York, Lake Erie & Western, Boston & Albany, Lake Shore & Michigan Southern and the Boston & Maine, and for wood frames the Delaware, Lackawanna & Western, Chicago, Milwaukee & St. Paul and Union Pacific, all of which show excellent design and construction. Your Committee respectfully suggest that the members of the association will give their close attention to the wearing qualities of steel and iron for tank and axles, in order that more definite information may be furnished.

We desire to express our thanks to the members of this asso-

ciation for the promptness in which our circular was answered, and for the care and trouble in providing the Committee with so large a number of elaborate blue-prints for the information, which will certainly be of value to the association.

R. C. BLACKALL,
JOHN MACKENZIE,
E. E. DAVIS,
THOS. PURVES, Jr.,
F. B. MILES,
Committee.

DISCUSSION ON TENDER-FRAMES.

On motion, the report was received.

Secretary SINCLAIR—I would like to have an explanation of why one road finds their frame costs $235 and another only $32.33.

Mr. MACKENZIE—The committee would like to have the same explanation.

Mr. PURVES—We received no blue-print from the P., W. & B.; but opposite the question relative to the cost of the tender-frame were the figures $32.33. I was quite anxious to see the blue-print of the frame that cost $32.33.

Mr. BROWN—As I stated to the committee, the reason why we considered the wood frame preferable to the iron one, is that the iron frame that we had—probably we may not have had the best, though we had some from different companies—when they get into a slight collision we have trouble with the bending down at the center. If it had been a wooden frame under such circumstances we would have had no trouble at all. You have got to take the whole thing to pieces. Probably the channel-bars are broken; if they are not broken they are bent. As I stated to them, we may not have had the best frame, and the $225 frame is a frame made for passenger engines. I thought that that amount was $200, the standard frame that we have for freight and coal engines. But $225 may have got in because we have some tender-frames for our passenger engines that cost $225.

Mr GENTRY—I was rather surprised to see that our Mr. Wade had not contributed any print or any information on this subject, as he prides himself on an iron tender-frame that he is using. I understood him to say that he was going to communicate with Mr. Blackall.

Mr. BLACKALL—I would say that the blue-prints we received would fill a good-sized flour barrel. We turned them all over to our secretary.

Mr. GENTRY—If you received ours I suppose you would have mentioned it. I see it is not mentioned. We commenced with an iron tender-frame, built by various locomotive builders, about ten years ago, and they were the most miserable things we ever tried to contend with, and we were

driven, some seven years ago, to design one for ourselves. We now have a very heavy steel tender-frame, which we think is a very good one. I am sorry to see that the committee did not get a chance to consider it. We do not make any difference between a tender-frame for a passenger engine and for a freight engine; we use just the same thing. We have also a very substantial arrangement in connection with what Mr. Barnett says—this is on the other subject—for the safety-chains. I will take pleasure in sending prints to any of the members who will ask for them.

Secretary SINCLAIR—I would like to explain about the blue-print matter. The roll of blue-prints came into the hotel within the last day or two. It is particularly large. I did not see that there would be enough wall space to put them all up here, so I thought it would be more satisfactory if I took them and consulted with the Executive Committee to see what would be engraved and what would be left out. It is impossible to engrave all these frames, but if any gentleman is interested in the examination of the prints, I will be very glad to have an interview with him after dinner.

Mr. BROWN—There is one little remark I wish to have understood. These tender-frames made for passenger engines were made previous to the adoption of the one that we intended as a standard, and they cost $225. But the standard is one that has been gotten up since, and we figured that at $200. That is the cost of it.

Mr. MACKFNZIE—I move that the discussion be closed.

The motion was carried.

The PRESIDENT—I wish to ask the secretary if he has any further communication that he desires to present at this time?

Secretary SINCLAIR—That finishes the regular reports. I have a report here on Locomotives in Argentine, prepared by a member of this association who is a mechanical superintendent there. It has been considered by the Executive Committee and decided as suitable for submission to this association. The subjects brought in are, however, not of a character suitable for discussion, and it occurs to me that it would suit the interests of all parties just as well if it was printed in the report and allowed to appear in the report without being read—a thing which has been done on several occasions.

Mr. MACKENZIE—I move that the report be received and printed in the proceedings.

The motion was carried.

LOCOMOTIVES IN ARGENTINE.

The following are extracts from a report made recently to the president of the department of engineers of the railroads of the Argentine Republic, made by a member of our association and other experts. The report gives a comparison of English and American locomotives which ought to be interesting to the members of this association. The Western Railway of Argentine,

which had an equipment of rolling stock made in the United States, obtained control of the Southern Railway of Argentine, which was entirely equipped with rolling stock made in England. The object of an investigation made, was to find out the relative value of the two kinds of rolling stock. We quote from the report:

"All the rolling stock of the Southern Railway was manufactured in England. As regards quality of material and its strength, it is all that could be desired; but the builders did not take into account the character of road-bed and track on which it was to run, and, therefore, made it too heavy, and the wheel-base too rigid.

"The locomotives might have run well enough on European roads, which are substantially built and well ballasted; but such is not the case in this province, where most of the railways are built on loose soil, especially those of this company, and subject to frequent inundations.

"The result is a large increase in the cost of maintenance of way and repairs to rolling stock, and, consequently, a heavier burden on the income of the road, and a proportionate reduction of interest on capital.

LOCOMOTIVES.

"Class 5 (Beyer, Peacock & Co., Manchester).—These locomotives were intended for the express trains running between Buenos Ayres and Mar del Plata; but the results of their trial trips were so unsatisfactory that the company was compelled to use them for ordinary passenger service.

"These locomotives have a single driving-axle, Crampton system, and the adhesive weight upon it is 29,392 pounds, or 14,696 pounds upon each wheel. This, even with a working pressure of 160 pounds per square inch, is insufficient to obtain adequate tractive power. This should have been borne in mind, as the trains to Mar del Plata are generally composed of fifty to sixty axles: that is to say, a weight of 350 to 400 tons.

"Practical experience has demonstrated that the locomotives built for this service should have two-coupled axles, and an average weight of not less than 8 tons upon each wheel, to afford adequate tractive power. Although this weight appears to be excessive, it is necessary to give steadiness to the locomotive when

running at a high rate of speed. At the same time, the weight of the train mentioned above should be taken into account, as well as the kind of road and the resistance of the prevailing high winds to the surface presented by a train of this class.

"All these reasons lead us to believe that this point was not sufficiently studied by the engineers of the company when building the road, and when ordering the locomotives. The Crampton type of locomotive is applicable to trains of less weight than it is to the interest of the company to run. None of the centers of population traversed by the lines of this railway is in condition to require the service of very rapid trains, but of trains running at a moderate rate of speed, and keeping exact time.

"Examining the weight of the locomotive, the unequal distribution upon each axle will be noticed, and the effects of this will be noticeably injurious to the permanent way. The high pressure, 160 pounds per square inch, at which the boiler is worked, becomes necessary to overcome somewhat the lack of adhesion. From close observation, we have noticed that this kind of locomotive, when running at less than usual speed and against a moderate wind, so easily primed, and to such an extent, as to make further running impossible.

"Class 6 (Beyer, Peacock & Co., Manchester).—This class of locomotives is fitted for the service of passenger and mixed trains.

"Of all the locomotives owned by the company, these are the most suitable for the road; but even these show the weight imperfectly distributed, there being an excess of more than 10,373 pounds on the bogie. The system of supports is inferior. While the absence of equalization permits of replacing the springs more readily, it has the disadvantage of making it impossible to distribute the shock due to inequalities of track. They have, moreover, a swing-bar which connects the two fore springs—a system which has been abandoned owing to its inefficiency.

"The excessive pressure at which the boilers are worked necessitates frequent and important repairs, such as the renewal of most of the tubes and stacks. The tube-plates and the fireboxes are destroyed in a short time, notwithstanding the good quality of the material, owing to the high pressure of 160 pounds per square inch, although higher pressure should be admissible without doing injury.

"All this is well proven by the cost of repairs, which amounts in two years to the sum of $1,800 gold.

"Class (Compound). (Beyer, Peacock & Co., Manchester).—These locomotives are used for the passenger and mixed train service.

"These locomotives are of high and low pressure, Worsdell and Von Borries system, having two cylinders, one high pressure and one low pressure.

"It is evident that this system of locomotives for passenger trains was adopted without proper consideration of the conditions of service. Their greater weight as compared with the high-pressure locomotives, the repairs required by them, the qualifications of the men who were to run them, should have been taken into account. Above all, it should have been borne in mind that the inventors of several systems of compound locomotives have found that an economy of 18 to 20 per cent. at a low rate of speed was reduced to 2 per cent. when the speed exceeds 30 kilometers an hour. Therefore, if all their economy does not compensate for their greater cost and the cost of repairs to permanent way, no practical advantage can be derived from the adoption of this system for our roads.

"How small the economy of fuel realized in these over the consumption of the high-pressure locomotives is, may be seen by comparing the consumption of the latter with that of the locomotives of the Class 6.

"The distribution of weight of this type is also very unequal, making a difference of over 13,466 pounds in excess upon the bogie--a very notable excess, since the average weight per square centimeter of surface of the road is 638 pounds.

"The pressure required in the boilers of these locomotives is 175 pounds per square inch, this being necessary to obtain useful work; but this has the inconvenience of necessitating continuous and serious repairs to the boiler. The journal-boxes are repaired and replaced very frequently, owing to the rigidity of the springs, and, as if this were not enough, the cylinders are very easily striated, according to the engineers of the company, by the heavy weight of the piston, but due, in our opinion, to a blunder of construction, which prevents the stem or rod of the piston from keeping its center in relation to the axis of the cylinder. The intercepting-valve, with which these locomotives are fitted, and

which helps them to start with the low-pressure cylinder, in case the piston of the high-pressure cylinder is at the dead point, must work automatically; that is to say, it must put the boiler in communication with the low-pressure cylinder when the locomotive stops, by means of a small auxiliary pipe. But it happens that it never works with regularity, and we have noticed in many cases that it requires from eight to ten minutes to start the train, having to back or reverse in order to effect this, a circumstance which generally causes the breaking of the traction-hooks and bars, without taking into account the annoyance to the passengers from the heavy jerks, or the delays occasioned by the time required to take out the damaged vehicles and transfer the passengers.

"Class 7 (Beyer, Peacock & Co., Manchester).—These are high-pressure locomotives, and are used for freight train service.

"These locomotives can only be examined from the standpoint of their weight, and a bad distribution of same. The total weight is 94,741 pounds, on the four axles, which we consider excessive, bearing in mind that the locomotives, Class 8, of the Western Railway, applied to the same service, and which were also built at the Beyer, Peacock & Co. works, weigh only 78,287 pounds, with cylinders of the same diameter and stroke, and having a powerful traction, with a consumption of 34.6 pounds per mile.

"Class 7 A (Compound). (Beyer, Peacock & Co., Manchester).—The locomotives of this class are intended for freight service.

"These locomotives have the same defects as those of Class 6, but in the consumption of fuel they are worse. The distribution of the load over the axles is very unequal, there being in this case a difference of over 7,508 pounds more on the bogie, the load being the heavier, as it has only one axle.

"In these, as in the previous ones, the repairs are very expensive, as may be seen from the detailed data given above.

"Class 7 B (Compound). (Beyer, Peacock & Co., Manchester).—These locomotives, like the previous ones, are for freight trains.

"The only difference between these locomotives and those of Class 7 A, consists in the cylinders, wheels and weight, as may be seen in the specifications. The economical results are the same, but the distribution of the weight over the axles is more unequal and more noticeable in these, if we take into consideration the location of the axles, a blunder having been made in leaving a

space of 61.4 inches from center to center between the driving-axle and the fore coupled-axle, whereas the distance between the rear coupled-axle and the driving-axle is 99 inches. In effecting the distribution of weight, the aim should be to make it as even as possible, in order to avoid greater stress on some parts of the track than on others, thus keeping down the cost of repairing it; but in this case not only has this been overlooked, but the error has also been committed of not having made equal the distances between the centers of the axles and of making them shorter at the point where the traction is more powerful.

"The Southern Railway has no grade so heavy as might compel it to adopt these types of locomotives, the disadvantages of which are seriously detrimental to its interests. The load of weight per square centimeter of surface of these different types of locomotives may be summed up thus:

Class 6	638	pounds.
Class 7	620	"
Class 7 A	638	"
Class 7 B	765	"

"These weights can be borne by roads or track built on hard wood sleepers and ballasted with stone or gravel, because such roads facilitate the distribution of weight over the whole track and are dry at all seasons; but the same cannot be said of the roads of this country, which are built with the Livesay bearings and on the natural ground, most of which is very compressible, so that the use of said locomotives on these roads occasions an increase of 60 per cent. in the cost of repairs to road-bed, besides hastening the destruction of rolling stock as a consequence of the bad condition of the roads.

AMERICAN ROLLING STOCK.

"The American rolling stock is much more suitable for our roads, because of the similarity in the construction and the nature of the ground in the United States and our country, and because of its simplicity, reduced weight, and improved system of equalization. Moreover, it costs less, and necessitates much less expense for keeping it in repair than the European stock.

"The American locomotives owned by the Western Railway, which were acquired when this road was the property of the State, by the engineers, Messrs. Miguel Tedin and Luis Rapelli,

are ten for rapid trains, eight for freight trains, and twelve for switching, and were built at the Baldwin Locomotive Works, of Philadelphia, in 1889. The same works built, in 1884, thirty locomotives for mixed trains, for the railway of this province.

"The construction of these sixty locomotives, notwithstanding its simplicity, is first-class, except in a few small details, which by no means affect their good conditions for service. The thirty locomotives for mixed trains have withstood very severe tests during the period when the railway had not the number necessary for its service, as, notwithstanding the excessive amount of work imposed upon them, the results have been very satisfactory and economical.

"In order to show better the good condition of these locomotives, it is necessary to specify their principal features, which will be found in the annexed table.

"It would suffice to compare the above data with those of the Southern Railway locomotives, to realize the superiority of these as regards the good distribution of the weight, cost of engine and cost of repairs. As to the consumption of fuel, they appear to be more economical, because the trains they draw are much lighter than those of the Southern Railway.

"The repairs they require are inconsiderable; their boilers continue in perfectly good condition; and in nine years' service it has been only necessary to renew the tubes of fifteen locomotives, the fireboxes and the tubes and boiler-plates being in good condition. The system of equalization is superior, having equalizing levers to connect the springs on each side, and the results have been good, even at a time when the road was in bad condition.

"Class 14 (Baldwin Locomotive Works, 1889).—For express trains.

"An examination and comparison of these data with those of the Southern Railway locomotives will show the defects of the latter. The American locomotives have a very large firebox to burn wood, 119 square feet of surface, and with a consumption of 30.1 pounds per mile, of coal per train kilometer, develop a pressure of 135 pounds per square inch, this being relatively economical; but it must be borne in mind that the trains of the Western Railway are generally all composed of American parlor cars, and that few of these trains weigh over 120 to 150 tons, or about one-third the weight of the Southern Railway trains.

"In tractive power the American locomotives are first-class, and, with trains composed of twenty-five parlor cars, they have developed a speed of fifty or sixty kilometers an hour, and a higher speed could have been attained, had it been desired, and had the state of the road permitted. The distribution of the weight over the axles is even in all, and this is one of the good features combined in them. So far their boilers, during their three years' service, continue in a perfect state of preservation.

"The repairs they have to undergo are inconsiderable, and confined only to the renewal of the bearings and the turning of the tires.

"Class 15 (Baldwin Locomotive Works, 1889).—For freight trains.

"These locomotives, like the preceding, are very good; their work and preservation are unsurpassed in good results. The weight on the axles is also even on all of them, this being one of their best features for our roads.

"It may be concluded, from all the data furnished in this report, that the Southern Railway locomotives are but iron masses, entirely injurious to the roads and interests of this company, and that a large part of its rolling stock is unnecessary for the service of its lines, as neither the condition of its roads nor the necessities of its traffic require it.

"Many years will elapse before it will be necessary to run very rapid trains on the roads of this province, and yet this company owns five locomotives (Class 5) for this service, which it is at present compelled to have laid by, having no use for them, and being obliged to pay the interest on the capital which they represent, out of the product of work which is not shared by them.

"So unfavorable has been the result of the compound locomotives (Class 6 A), that it was necessary to withdraw them from the Mar del Plata service last summer, and to use in their place the freight locomotives, owing to the tractive power of the former being less than was required.

"We think that the foregoing report is sufficiently specific to enlighten the president, and to justify us in asking him to decree that no company be allowed in future to import into this country their locomotives, without first presenting and submitting their plans to the approbation of this department."

TABLE SHOWING THE COMPARISON OF ENGLISH AND AMERICAN LOCOMOTIVES IN THE ARGENTINE REPUBLIC.

	Built by Beyer, Peacock & Co., Manchester, England.						Baldwin Locomotive Works.		
	Class 5.	Class 6.	Class Compound.	Class 7.	Class 7 A, Compound.	Class 7 B, Compound.	Class 11, 1884.	Class 14, 1889.	Class 15, 1889.
Diameter of cylinders (inches)	16.4	16.4	H.P. 16.4	18.	H.P. 16.9	H.P. 18.1	15.	17.	18.
Diameter of cylinders (inches)	......	......	L.P. 23.2	......	L.P. 24.4	L.P. 26.	......	......	......
Stroke of piston (inches)	24.	24.	24.	24.	24.	26.	20.	24.	24.
Heating surface of firebox (sq. feet)	85.	86.	85.	86.	86.	117.	77.2	119.	96.1
Heating surface of tubes (sq. feet)	929.	984.	929.	990.	1,000.	1,153.	826.7	1,169.	1,076.6
Diameter of driving-wheels (inches)	76.7	68.	68.	61.4	61.8	55.5	60.	72.	54.
Diameter of carrying-wheels (inches)	49.	......	......	......	......	......	......	......	......
Diameter of truck-wheels (inches)	38.	38.	38.	39.3	41.	38.	36.	36.	29.3
Weight upon driving-axle (pounds)	29,392.	24,723.	25,814.	25,286.	25,124.	26,739.	24,301.	30,725.	22,110.
Weight upon carrying-axle (pounds)	20,444.	......	......	......	......	......	......	......	......
Weight upon first-coupled-axle (pounds)	......	24,501.	25,540.	24,054.	24,662.	26,846.	24,301.	30,725.	22,110.
Weight upon second-coupled-axle (pounds)	......	......	......	24,957.	26,210.	24,646.	......	......	22,110.
Weight upon truck-axle (pounds)	36,665.	35,096.	39,281.	20,444.	33,719.	33,719.	24,301.	30,725.	22,110.
Total weight of engine in working order (pounds)	86,501.	84,320.	90,635.	94,741.	109,715.	111,948.	73,903.	92,175.	88,440.
Maximum pressure of steam (pounds)	......	160.	175.	155.	175.	175.	135.	135.	135.
Weight per square foot of surface (pounds)	......	638.	638.	620.	638.	696.	462.	572.	462.
Average consumption of coal per train mile (pounds)	34.	37.	34.6	51.5	38.	39.7	24.8	30.1	43.3
Average mileage per month (miles)	2,485.	2,795.	2,981.	2,485.	1,553.	1,553.	2,485.	3,105.	2,173.
Cost on board in the port of Buenos Ayres	$14,238.00	$14,238.00	$15,483.00	$16,279.00	$16,667.00	$17,967.00	$8,200.00	$11,750.00	$12,125.00
Cost of keeping two years in good repair	$1,800.00	$1,800.00	$1,800.00	$1,950.00	$1,950.00	$1,950.00	$500.00	$500.00	$500.00

The PRESIDENT—The next will be the report of the Committee on Subjects.

Secretary SINCLAIR—Mr. President, the Committee on Subjects submits the following report:

SUBJECTS FOR NEXT CONVENTION.

1. What method of construction can be devised to prevent the cracking of the back tube-sheet?

2. Devices to facilitate the oiling of fast passenger engines when on long continuous runs; and effective cylinder lubrication with high-pressure steam.

3. The value of locomotive fire kindlers and their relation to fire insurance risk.

4. Exhaust nozzles and steam passages.

5. Standard specifications and tests for boiler and firebox steel to be recommended for adoption by this association.

6. Modern sanding devices.

7. Special shop tools, either hand, power, pneumatic or electric, applied or applicable to locomotive manufacture and repair.

8. The recommendation of a uniform system of examination and test of boilers in actual service, more especially for the discovery of broken stay-bolts.

9. Tire treatment—what is the amount of shrinkage to be allowed for large driving-wheels? Is there any necessity for tire retaining rings or clips? What is the limit of thickness that various diameters of tires should be worn down to before being scrapped? What is the greatest allowable depth of groove worn in tread before tire should be turned up in lathe?

WM. SMITH,
E. M. ROBERTS,
J. DAVIS BARNETT,
Committee.

Mr. LEWIS—I move that the report be received and referred to the Executive Committee.

The motion was carried.

The PRESIDENT—I wish at this time, gentlemen, to announce the Committee on Subjects for the ensuing year. They are: Mr. Mitchell, Mr. Barnett and Mr. T. Purves, who will consider the subjects that they will present here one year hence. Is the report of the Committee on Resolutions ready?

The report of the Committee on Resolutions was read by Mr. Pomeroy as follows:

REPORT ON RESOLUTIONS.

The thanks of this association are due and are hereby tendered to the New York, Lake Erie & Western Railway, the Western New York & Pennsylvania, the Chautauqua Lake Railway, the Brooks Locomotive Works, *The Railway Age and Northwestern Railroader*, the Chautauqua Assembly, Mr. Sampson Fox, Mr. George Royal, the proprietors and management of the Kent House and of the Sterlingworth Inn, the officers of the association, Messrs. Sibley and Miller, and to Messrs. A. E. Mitchell and S. Higgins, of the motive power department of the New York, Lake Erie & Western Railway Company.

L. R. POMEROY,
G. R. HENDERSON,
R. D. WADE,
Committee.

Mr. MACKENZIE—I move that the report be received and spread on the minutes.

The motion to receive the report of the Committee on Resolutions was carried.

CHANGE OF BY-LAWS.

Secretary SINCLAIR—It is necessary to change one of our by-laws. Two years ago, I think it was, we arranged with the Master Car Builders' Association that they should meet on the second Wednesday of June and we should meet on the Monday following. Last year they changed their day from Wednesday back to Tuesday. Our by-laws read: "The regular meeting of the association shall be held annually on the Monday after the second Wednesday in June." Now it should read, "after the second Tuesday in June," or we might have to meet on a different day from what our by-laws require. Therefore, I move that we change the first article of the first by-law to read: "The regular meeting of the association shall be held annually on the Monday after the second Tuesday in June." I might explain that we can change our by-laws at any time, while to change the constitution we would have to give a year's notice.

The motion was carried.

ELECTION OF OFFICERS.

The PRESIDENT—The next business, gentlemen, is the election of officers. You will proceed to ballot for President.

Secretary SINCLAIR—Before the election of officers goes on, I would

like to explain that Mr. Garstang, our 1st Vice-President, is absent, owing to sickness. He wrote to me, wishing that I would explain how warmly he felt toward the interest of the meeting, but sickness and other matters prevented him from being present. I think this is the right time to put that before you.

The PRESIDENT—We will now proceed to the election of President. Mr. Gentry and Mr. Purves will please act as tellers. The election of officers will go on without nomination. No nominations are to be made in the election of officers in this association. They must be elected by ballot separately.

Secretary SINCLAIR—The whole number of votes cast is 67. Mr. Hickey received 51, Mr. Garstang 11, and there were 5 scattering. Mr. Hickey is elected.

Mr. HICKEY—Gentlemen, I desire to thank you for this further mark of respect and confidence. I shall endeavor in the future to do my duty to the association, as I have in the past. I trust that we will all work together, and next year make as good a Convention, at least, as we have this. I shall work certainly for the benefit of the association, and again I thank you. (Applause.) You will prepare your ballots for 1st Vice-President.

Mr. GENTRY—We find in the hat a large number of blank ballots. I suggest that the members who do not vote refrain from throwing into the hat any blank pieces of paper. It only bothers us.

The secretary announced the vote for 1st Vice-President as follows: Mr. Garstang, 55; Mr. Blackall, 5; scattering, 6.

The PRESIDENT—Mr. Garstang is elected 1st Vice-President. You will now proceed to ballot for the 2d Vice-President.

The secretary announced the vote for 2d Vice-President as follows: 65 have voted; 60 for Mr. Blackall and 5 scattering.

The PRESIDENT—Gentlemen, R. C. Blackall is elected 2d Vice-President of this association.

You will next prepare your ballots for Treasurer.

The Convention then proceeded to ballot for Treasurer.

Secretary SINCLAIR—Mr. President, 58 voted; 53 for O. Stewart and 5 scattering.

The PRESIDENT—Gentlemen, I announce that Mr. Stewart is elected Treasurer of this association. We will now proceed to the balloting for Secretary.

The Convention then balloted for Secretary.

Mr. POMEROY—The total number of votes cast is 54, 52 of which are for Mr. Angus Sinclair.

The PRESIDENT—I declare Mr. Angus Sinclair elected Secretary of this association.

WHERE THEY WISH NEXT CONVENTION TO BE HELD.

Before adjourning, I wish to add that it is customary to get an expression from the members as to where they desire to meet the following

year, and I would like now to get such an expression with respect to our next meeting. You are aware that the Executive Committees of the Master Mechanics' and the Master Car-Builders' Associations settle on the place of meeting. But it is customary to get an expression of opinion from the members before adjournment, and I would like to hear from you now.

The following places were named by different members: St. Paul, St. Louis, Saratoga, Old Point Comfort.

The PRESIDENT—We will now hear Mr. Baker, who desires to say something to the Convention.

G. H. BAKER RETURNS THANKS.

Mr. G. H. BAKER—I am informed that I was elected an Associate Member of this association yesterday while I was absent from the room, and I wish to express my appreciation of the courtesy conferred by the members. During some sixteen years of my railroad experience, as a fireman, as an engineer, as a specialist on locomotives, as a master mechanic, and, during the last couple of years, as a railroad newspaper man, I have become very well acquainted with the master mechanics and have arrived at a very high appreciation of their ability and sound common sense. The scientific attainments of a large number of the master mechanics of this country are of a high order, but as the best practical proof of their superior ability I would point to the modern locomotive of to-day, which excels in speed and tractive power the locomotives of the world, and the excellencies of the construction of which are rapidly modifying the construction of the locomotives on nearly every railroad in every country in the world. I have long had a deep interest in the aims of this association, and it will always be a pleasant duty for me to do what I can to further those aims in every possible way. (Applause)

NO PRESIDENT TO SUCCEED HIMSELF.

Mr. DAVID CLARK—Mr. President, I now make a motion that after this year no presiding officer can succeed himself.

Mr. LEEDS—I second that motion.

The PRESIDENT—You have heard the motion—a very important one—that after this year the presiding officer of this association shall not succeed himself.

Mr. CLARK—That means a one-year term.

The PRESIDENT—That means a one-year term ; yes, sir. We will take a rising vote.

The motion was carried.

The PRESIDENT—Now, gentlemen, as that ends the official business of the association, I desire to thank you for the uniform courtesy and support that you have given the chair. I shall always remember it, and in connection with that I desire to commend your good work. You have done splen-

didly. Our Convention, I think, has been a successful one. I have just been told by the secretary that we have received $800, being $50 more than we ever received during any Convention of the past. That shows the interest that we are taking. Now, gentlemen, I hope that you will all return to your homes safely and find your families in the best of health and spirits, and I trust that a year hence you will all appear at your Convention and do as good work as heretofore.

On motion of Mr. Gentry the Convention then adjourned.

Obituary.

N. E. CHAPMAN.

N. E. Chapman was born April 6, 1829, at Tolland, Conn. At the age of seventeen he went to Hartford to learn the machinists' trade and for a time worked at Colt's Armory, and came to Cleveland in 1851, engaging with the Cuyahoga Works. Owing to the panic in 1857, the works closed and Mr. Chapman accepted the position as foreman of the shops at Zanesville, Ohio, of what is now a part of the Baltimore & Ohio Railway system.

In August, 1863, he returned to Cleveland to take the position as foreman of the Cleveland & Pittsburgh Railroad shops, and was appointed master mechanic of that road on March 1, 1864, in which capacity he remained up to March 1, 1882. At this date he was appointed superintendent of motive power of the Baltimore & Ohio Railway system, but owing to ill health, he resigned in the summer of 1883 and sought relief for his trouble (rheumatism) at the springs.

In the early fall of 1883, he engaged with the Midvale Steel Company, remaining with this company up to the first of January, 1888.

During the summer of this year (1888) he became interested in the Latrobe Steel Works, representing them up to the time of his death, which took place on January 8, 1893.

Mr. Chapman was an earnest and faithful worker for the interests of our association, having with credit to himself and to the association, served in all phases of the work from committee work up to president of the association. This latter position he held for two years, 1877–1878 and 1878–1879.

Quiet and unassuming, faithful to every trust, respected by all,

he kept a host of warm friends ; as another has well expressed it, "he was cheerful and kind to all, having the advantage of most men in dealing with those under him, of always having a kind word for all," and his innate good sense and ability of smoothing the rough pathways of life, encouraging those who felt aggrieved and lifting up the fallen, was a conspicuous element of his character.

Mr. Chapman leaves a wife and son who have the sympathy of hosts of friends in their loss.

L. R. POMEROY,
J. N. LAUDER,
GEO. W. STEVENS.

JOSEPH S. PORTER.

Joseph S. Porter was born in Brandon, Suffolk county, England, and came to Sandusky, O., when he was a boy. His father was employed on what was then the Mad River & Lake Erie Railroad, and he entered the shops of that company as an apprentice in the spring of 1851, where he continued working as a machinist until March, 1865, when he was transferred to Dayton, O., as foreman of the roundhouse.

When the part of the road between Dayton and Springfield was leased he was transferred to Springfield, where he remained until 1880, when he was appointed master mechanic of the road and again transferred to Sandusky, and occupied that position until his death, October 27, 1892.

He became a member of this association at the meeting of 1881.

Mr. Porter was a conscientious officer, faithful in the discharge of his duty, as his long service on the one road fully attests.

He was twice married, and leaves a wife, three sons and three daughters to mourn his loss.

WM. SWANSTON,
WM. GARSTANG.

H. L. LEACH.

Henry Lowell Leach was born in Haverhill, Mass., May 6, 1821. When he was about a year old his parents moved, with him, to Amesbury, Mass., and it was here he spent his boyhood days and obtained a common school education.

At the age of twenty-one, having served three years apprenticeship to the blacksmiths' trade, and not feeling satisfied to work any longer in that capacity, he went to Merrimac, Mass., to learn to make what was known as the "Elliptic carriage springs," a business which was at that time in its infancy. Here he was employed for about six months, after which he went to Andover, Mass., to learn the machinists' trade. Here he remained for six months. He then, in 1843, secured a situation with Messrs. Hinckley & Drury, locomotive builders in Boston, and it was here that he afterwards made for himself a most honorable reputation.

He was now twenty-two years of age, and worked under Mr. William Lowell, who was in charge of what was known as the "Wheel and Axle Job," for a number of years, and after the death of Mr. Lowell he succeeded him in this part of the business, which was at that time carried on by the piece-work system. It was while so employed that his income enabled him to purchase an interest in the business, which was wiped out when the company failed in 1857.

About this time Mr. Leach, being out of business and in ill health, moved back to Amesbury and lived on a farm until 1861.

In the meantime the Hinckley Works was reorganized under the name of the Hinckley & Williams Works. After running but a short time Mr. Leach was asked to again take the "Wheel and Axle Job," and later, in connection with Mr. John Daniels, carried on, under this piece-work system, the whole of the locomotive building, with the exception of the boiler and blacksmith departments. The business was managed in this way for about two years, after which he was appointed superintendent, and after the death of Mr. Williams, general manager.

It was a disastrous blow to Mr. Leach when this concern again suddenly collapsed, owing to the stringency of the money market, and the earnings of his best manhood were swept away. It was

at this crisis that the sturdy quality of the man asserted itself. Although nearly sixty years of age, he possessed the vigor of a much younger man, and with the same determination to succeed which had characterized his whole life, he again started in business, establishing in Boston a profitable agency for railway supplies, and continued in this business until his death, which occurred on May 14, 1893, of pneumonia, at the age of seventy-two years. Through all these vicissitudes the name of Henry L. Leach has stood for tireless energy, unswerving integrity and sympathetic consideration for his associates.

Mr. Leach was a member of the Masonic order, and for years held a prominent position in the Massachusetts Charitable Mechanics' Association.

HENRY L. LEACH, JR.,
GEO. RICHARDS,
JNO. THOMPSON.

DAVID PRESTON.

The death of Mr. David Preston, the mechanical superintendent of the Canadian Pacific Railway, which occurred at Montreal on the 13th of April, leaves a gap in the ranks of the railroad pioneers of forty years ago. The deceased was of Scotch parentage, and was born near Guthrie, in Forfarshire, on the 23d of May, 1830. He received a good education, and began life in the service of the Scottish Midland & Aberdeen Railway. At the age of twenty-four he came to Canada. After his arrival he was for a short time engaged in the work of building the famous tubular bridge, which carries the tracks of the Grand Trunk Railway over the St. Lawrence at Montreal. He was subsequently employed on the Grand Trunk, running an express engine between Toronto, Belleville and Kingston. His ability and faithful service soon raised him to the position of foreman of the company's shops at Toronto. In 1877 he accepted the post of mechanical superintendent of the Toronto, Grey & Bruce Railway. This road runs from Toronto to the port of Owen Sound, on the Georgian Bay, and was then narrow gauge. At the time Mr. Preston was selected to take charge of the mechanical department, the Toronto, Grey & Bruce Railway Company was contemplating a change of gauge to the standard, 4 ft. 8½ in. Most of the locomotives on that line had been built in Great Britain, and their conversion was by no means an easy task, with the comparatively limited stock of machinery then owned by the company. In 1883 the Canadian Pacific Railway, then only three years in existence, leased the line just built from Toronto to Perth, reaching Montreal via Ottawa by the old Brockville & Ottawa and the Quebec, Montreal, Ottawa & Occidental Railways.

At the same time it acquired the T., G. & B. and the Credit Valley Railways. Mr. Preston was appointed division master mechanic by the Canadian Pacific Railway and given charge of the newly built and acquired lines in Southern Ontario. He was afterwards given charge of the main line from Port Arthur to Montreal, in addition. In the early part of 1890 he was promoted to the position of mechanical superintendent over the whole line, covering upward of 6,000 miles. This position he

held up to the time of his death. Mr. Preston possessed in a great measure the rare faculty of managing and controlling men. The possession of this quality was a fact which largely assisted in his own advancement. Throughout his successful career he was always the firm friend and helper of all younger aspirants to success with whom he came in contact. It can be truly said of him that he achieved his position—passing through the various grades to the highest place in the profession—without trampling on the rights of a single fellow-employé. He died universally regretted by all the officials of the company with whom he had been in contact, and was regarded as one of the kindest-hearted men that ever occupied such a position.

R. Atkinson.

ISAAC DRIPPS.

The little circle of charter members of this association was narrowed down again by the death of Isaac Dripps on December 28, 1892.

Mr. Dripps was born in Belfast, Ireland, April 17, 1810, and came to this country with his parents when a mere child.

At sixteen years of age he became an apprentice to Thomas Holloway, of Philadelphia, who then had one of the largest machine shops in that city and made a specialty of marine work. Mr. Dripps became a foreman before he was twenty years old, and was in charge of extensive repairs to the steamer *Swan* in New York harbor when he became of age.

He resigned at this time and entered the employ of Robert L. Stevens, president of the Camden & Amboy Railroad, and received, set up, and ran the famous locomotive "John Bull."

He now took charge of the company's shops at Hoboken and built seven locomotives, and got them into service at South Amboy—men had to be taught to handle them—by the time the company were ready to transport passengers by steam. This was in the fall of 1833. At this time Mr. Dripps was made superintendent of machinery, and he was the first man to hold that title in America. He had charge of all the floating equipment, as well as the railroad machinery.

Mr. Dripps designed the large stack with inside pipe and cone, he put the first deflector-plate in a smoke-arch, invented the combustion chamber—using two sets of flues—and put in the first high, single nozzle, all before the close of 1834.

To Isaac Dripps belongs the credit of making the first single screw propeller; he had charge of the steam propeller "Commodore Stockton," afterwards renamed the "New Jersey," built in England by Capt. John Ericsson in 1839. This boat had two screws, revolving in opposite directions to prevent listing of the boat—they were unsatisfactory, the engines complicated, and the hollow shaft troublesome. In 1840 Mr. Dripps overhauled the boat, put in a simple engine and built a six-bladed single screw that was a success from the start, and ran the boat for more than a quarter of a century. From 1853 to 1857, Mr. Dripps was superintendent and part owner of the

Trenton Locomotive & Machine Works, at Trenton, N. J., and while there designed and built, for the Belvidere & Delaware Railroad, the first diamond truck.

In 1859 he was appointed superintendent of machinery of the Pittsburgh, Fort Wayne & Chicago road at Fort Wayne, Ind., and built the shops there—for years the model railroad shops of America. In 1869 Mr. Dripps retired from this position on full pay.

When the Fort Wayne road was leased by the Pennsylvania, Mr. Dripps was appointed "inspector of shops, tools and machinery of the main line and branches of the P. R. R. system, and all lines owned, operated and leased by it."

In this position Mr. Dripps closed up small shops, consolidated the work and arranged for standardizing the power over the whole system. He designed and equipped the car shops and foundry at Altoona, and equipped the Panhandle shops at Logansport, Ind.

The last work done by Mr. Dripps was in conducting a series of tests in 1878 with different classes of locomotives on the mountain curves and grades near Renova, Pa., which resulted in the adoption of the "Class R" consolidation locomotive as the standard freight engine of the system. At the close of these tests he retired from all active business, and from 1878 to the time of his death resided with his son in Philadelphia.

Isaac Dripps was the pioneer railroad master mechanic of America. Without experience, without precedent, with little material and with untrained men he made a success of the motive power of one of the first railroads on this continent, and left it the best equipped railroad in the world. He designed many of the devices in common use, and he planted the first seeds of shop standards that have made the way easy for those in the same calling who came after him.

To the first working locomotive engineer, the first railway master mechanic, the first superintendent of machinery of an American railroad, Hail and Farewell!

John A. Hill,
R. Wells,
F. D. Casanave.

A. T. WOODS.

Arthur Tannatt Woods, eldest son of Captain and Brevet Lieut.-Colonel George Henry Woods, born at Minneapolis, Minn., January 9, 1859, died February 7, 1893, at Chicago, Ill. He was graduated from the Naval Academy, Annapolis, as cadet engineer in June, 1880, and, after three years' service at sea, was promoted to assistant engineer on June 10, 1883. After serving one year in the Bureau of Steam Engineering of the Navy Department, at Washington, D. C., he was detailed to the University of Illinois, at Champaign, for duty in the Mechanical Engineering Department, as Assistant Professor of Mechanical Engineering, until June, 1887, when he was elected Professor of his department and resigned from the navy. He remained at the University of Illinois until September, 1891, when he was called to the chair of dynamic engineering at the Washington University, St. Louis. In September, 1892, he resigned from the Washington University to accept the position of associate editor of the *Railroad Gazette*, which he occupied at the time of his death.

Mr. Woods was given the degree of Master of Mechanical Engineering, from Cornell University, in 1890. He was a member of the American Society of Mechanical Engineers, a member of the Society of Naval Engineers, a member of the Western Railway Club, and associate member of this association. He was the author of a text-book on mechanism, a book on compound locomotives, and many valuable papers on engineering subjects. In addition to his editorial duties on the *Railroad Gazette*, Mr. Woods acted as consulting mechanical engineer in Chicago. Mr. Woods was a member of the Military Order of the Loyal Legion of the United States of the Commandery of the State of Illinois.

Mr. Woods, by his useful work and genial disposition and gentlemanly bearing, won the respect and regard of all of his companions and associates, and it was with sincere regret and sorrow that they learned of his sudden death, in the time of his greatest usefulness. To his widow and family this association extend profound sympathy.

D. L. Barnes,
George Gibbs,
William Forsyth,
Committee.

CHARLES R. PEDDLE.

Mr. Charles R. Peddle died April 19, 1893, at Terre Haute, Ind. Mr. Peddle, who was born in Philadelphia, Pa., October 5, 1820, was descended from a family of English Friends. He received a good education, spending the last years of his scholastic life at a seminary at Plainfield, Conn. As was the custom in those days, he was apprenticed to the well-known firm of machinists and engine builders, Norris & Son, Philadelphia, Pa., to become a mechanical engineer. From this establishment he went to Reading, Pa , where he worked for a time as a machinist, and was also an engineer on the Reading Railroad. In 1848 he came West, and was an engineer on the Madison & Indianapolis Railroad, then the only railroad in Indiana, under the presidency of the Hon. John Brough.

While at Madison he was married to Miss Elizabeth Marks in 1849, of which marriage two sons and two daughters survive. In 1851, when the late Chauncey Rose was looking for a capable man to build and operate the Terre Haute & Richmond Railroad, he was directed by Mr. John Brough to Mr. Peddle, whose services he secured. Mr. Peddle brought to the West the first rolling stock of the Terre Haute & Richmond Railroad—four small engines, built at Boston, Mass., two of which, with great labor and anxiety, were taken by way of Cincinnati and Madison to Indianapolis, and two via the Wabash and Erie Canal to Terre Haute—in 1851, as locomotive engineer and master mechanic of the road.

Until some time after the construction of the St Louis, Vandalia & Terre Haute Railroad, Mr. Peddle was superintendent, and superintendent of motive power and purchasing agent for the two divisions of the Vandalia line, he having been formally made general superintendent in 1870, with Mr. John E. Simpson as assistant on the T. H. & I. division and Mr. Conlogue as assistant on the Vandalia division. He resigned this office in 1871, in which he was succeeded by Mr. Simpson. He became purchasing agent when that office was organized in 1882, and held the position during the rest of his life.

Mr. Peddle's first wife died in 1864, leaving four young children, William H., Sarah, Charles R. and Elizabeth. Mr. Peddle married, in 1867, Miss Mary Ball. There survive Mr. Peddle, his wife, three sons and five daughters.

G. H. Prescott.

JOHN BLACK.

The death of Mr. John Black occurred at his home in Lima, Ohio, February 17, 1893. He was sixty-five years of age at the time of his death. He was born in Clackmannan county, Scotland, and during his early years was employed in a cloth factory. Came to America in 1850 and worked for a time in Boston and Lowell, Mass., in machine shops. Came West and became connected with the Niles Locomotive Works at Cincinnati, Ohio, as contractor, where he remained until he accepted a position as locomotive engineer on the Marietta & Cincinnati R. R. running out of Cincinnati. Leaving there, he took service with the Cincinnati, Hamilton & Dayton R. R. as engineer, about the year 1857. He continued in the service of this company as engineer until he was appointed master mechanic at Richmond, Ind., of the Richmond division of the C., H. & D. R. R., remaining at Richmond as master mechanic until 1865, when he was appointed general master mechanic of the Cincinnati, Hamilton & Dayton system, when he removed to Lima, Ohio, remaining at Lima until he died. Mr. Black was among the oldest members of the association, having joined at Philadelphia, September 14, 1870, and it loses by his death one of its oldest and most respected members.

C. H. CORY.

L. C. BRASTOW.

Louis Cornelle Brastow was born at Medfield, Mass., March 23, 1824; died at Wilkesbarre, Pa., April 15, 1893, of pneumonia. He learned the machinists' trade at Nashua, N. H. He was connected with the mechanical department of the Pennsylvania R.R. for about fourteen years, and with the Lehigh & Susquehanna R.R., now a division of the Central R.R. of N. Y., as superintendent of motive power for about twenty-six years. He was a mechanic of high order and ability, a good designer of machinery, and an excellent shop superintendent in all respects. His long-continued terms of service with his employers is the best evidence of his usefulness and worth. He was a man that was modest and unassuming, as well as courteous, in his manners. His name is spoken of by those who knew him with regard and admiration. The death of Mr. Brastow was a great surprise to his friends and employers. He was taken suddenly with chills on the Sunday previous to his death; up to his last illness he enjoyed perfect health. He is survived by a wife and three children—two sons and a daughter—to whom the association extend their sympathy.

W. Montgomery.

E. J. WHITTINGTON.

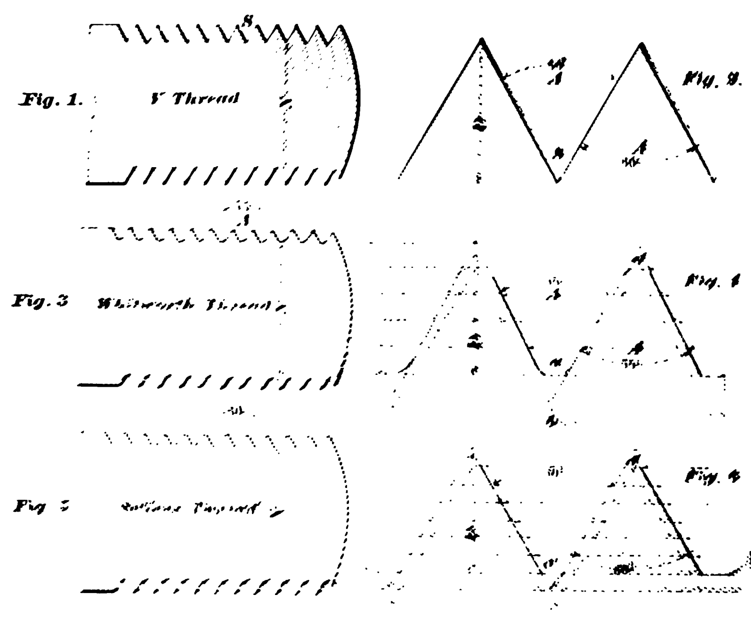
E. J. Whittington was born November 1, 1854, at Fayette, Howard county, Mo. He commenced work as an apprentice in the Wabash shops at Moberly, Mo., in 1874; continued in the employ of this company until 1882. He then went to Missouri Pacific Railway at Sedalia, Mo., as a machinist and continued in the service of this company three years. From there he went to the Atchison, Topeka & Santa Fé and was in their employ two years, then returned to Moberly as roundhouse foreman; continued in this capacity for about two years. In August, 1889, left Moberly to accept situation as division master mechanic at Slater, Mo., on the Chicago & Alton Railroad, in which position he continued until his death, which occurred March 20, 1892. He joined the association in 1890. Mr. Whittington leaves a wife and five children, who have the sympathy of this association.

ANGUS SINCLAIR,
Committee.

Standards Adopted by the American Railway Master Mechanics' Association.

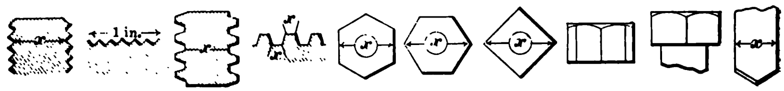
Screw Threads.

At the Third Annual Convention the report of a Committee recommending the United States standard screw thread was adopted. Annexed are the forms and dimensions of the threads in question.



The Association at the Twenty-fifth Annual Convention adopted

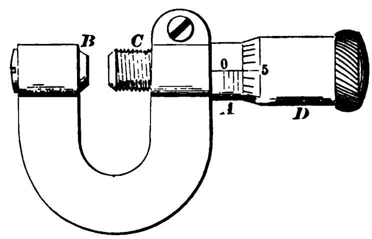
the United States standard sizes of nuts and bolt heads, particulars of which are given below :



Diameter of Screw.	Threads per Inch.	Diameter at Root of Thread.	Width of Flat.	Short Diameter of Hexagon or Square.	Long Diameter Hexagon.	Long Diameter Square.	Thickness Nuts.	Thickness Heads.	Tap Drill.
1/4	20	.185	.0062	1/2	37/64	7/10	1/4	1/4	3/16
5/16	18	.240	.0074	19/32	11/16	27/32	5/16	19/64	1/4
3/8	16	.294	.0078	11/16	51/64	63/64	3/8	11/32	5/16
7/16	14	.344	.0089	25/32	9/10	1 7/64	7/16	25/64	23/64
1/2	13	.400	.0096	7/8	1	1 15/64	1/2	7/16	13/32
9/16	12	.454	.0104	31/32	1 1/8	1 23/64	9/16	31/64	15/32
5/8	11	.507	.0113	1 1/16	1 7/32	1 1/2	5/8	17/32	17/32
3/4	10	.620	.0125	1 1/4	1 7/16	1 49/64	3/4	5/8	5/8
7/8	9	.731	.0138	1 7/16	1 21/32	2 1/32	7/8	23/32	3/4
1	8	.837	.0156	1 5/8	1 7/8	2 19/64	1	13/16	27/32
1 1/8	7	.940	.0178	1 13/16	2 3/32	2 9/16	1 1/8	29/32	31/32
1 1/4	7	1.065	.0178	2	2 5/16	2 53/64	1 1/4	1	1 3/32
1 3/8	6	1.160	.0208	2 3/16	2 17/32	3 3/32	1 3/8	1 3/32	1 3/16
1 1/2	6	1.284	.0208	2 3/8	2 3/4	3 23/64	1 1/2	1 3/16	1 9/32
1 5/8	5 1/2	1.389	.0227	2 9/16	2 31/32	3 5/8	1 5/8	1 9/32	1 13/32
1 3/4	5	1.491	.0250	2 3/4	3 3/16	3 57/64	1 3/4	1 3/8	1 1/2
1 7/8	5	1.616	.0250	2 15/16	3 13/32	4 5/32	1 7/8	1 15/32	1 5/8
2	4 1/2	1.712	.0277	3 1/8	3 5/8	4 27/64	2	1 9/16	1 3/4
2 1/4	4 1/2	1.962	.0277	3 1/2	4 1/16	4 61/64	2 1/4	1 3/4	1 31/32
2 1/2	4	2.176	.0312	3 7/8	4 1/2	5 31/64	2 1/2	1 15/16	2 3/16
2 3/4	4	2.426	.0312	4 1/4	4 29/32	6	2 3/4	2 1/8	2 7/16
3	3 1/2	2.629	.0357	4 5/8	5 3/8	6 17/32	3	2 5/16	2 5/8
3 1/4	3 1/2	2.879	.0357	5	5 13/16	7 1/16	3 1/4	2 1/2	2 29/32
3 1/2	3 1/4	3.100	.0384	5 3/8	6 7/64	7 39/64	3 1/2	2 11/16	3 1/32
3 3/4	3	3.317	.0413	5 3/4	6 21/32	6 1/8	3 3/4	2 7/8	3 11/32
4	3	3.567	.0413	6 1/8	7 3/32	8 41/64	4	3 1/16	3 19/32
4 1/4	2 7/8	3.798	.0435	6 1/2	7 9/16	9 3/16	4 1/4	3 1/4	3 13/16
4 1/2	2 3/4	4.028	.0454	6 7/8	7 31/32	9 3/4	4 1/2	3 7/16	4 1/32
4 3/4	2 5/8	4.256	.0476	7 1/4	8 13/32	10 1/4	4 3/4	3 5/8	4 9/32
5	2 1/2	4.480	.0500	7 5/8	8 27/32	10 49/64	5	3 13/16	4 1/2
5 1/4	2 1/2	4.730	.0500	8	9 9/32	11 23/64	5 1/4	4	4 3/4
5 1/2	2 3/8	4.953	.0526	8 3/8	9 23/32	11 7/8	5 1/2	4 3/16	4 31/32
5 3/4	2 3/8	5.203	.0526	8 3/4	10 5/32	12 3/8	5 3/4	4 3/8	5 7/32
6	2 1/4	5.423	.0555	9 1/8	10 19/32	12 15/16	6	4 9/16	5 7/16

SHEET METAL GAUGE.

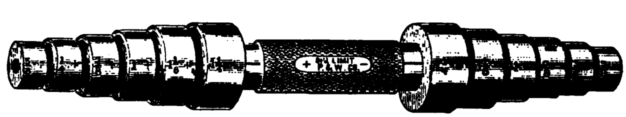
At the Fifteenth Annual Convention the Brown & Sharp micrometer gauge shown below was adopted as standard for the measurement of sheet metal.

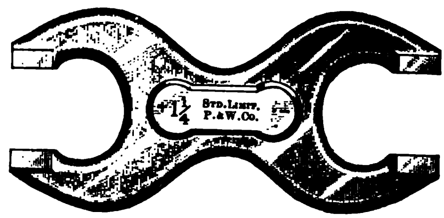


LIMIT GAUGES.

At the Seventeenth Annual Convention the Pratt & Whitney limit gauges for round iron, illustrated on this and following page, were adopted. The sizes are as follows:

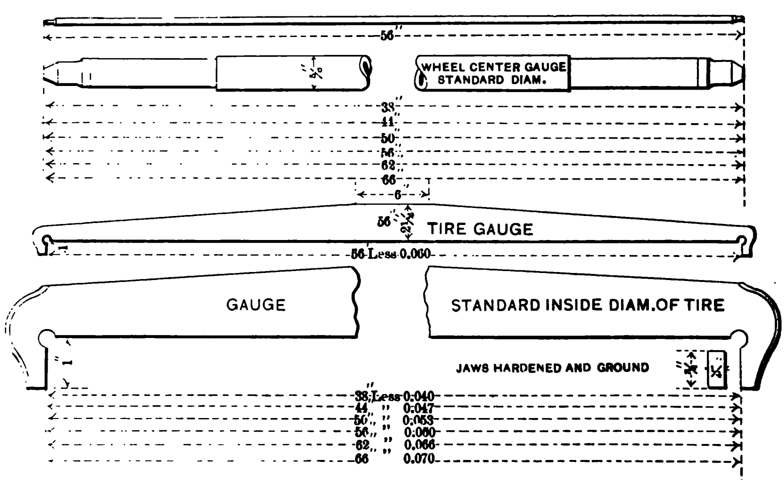
NOMINAL DIAMETER. OF IRON. INCHES.	Large Size, End. Inches.	Small Size, End. Inches.	Total Variation. Inches.
1/4	.2550	.2450	.010
5/16	.3180	.3070	.011
3/8	.3810	.3690	.012
7/16	.4440	.4310	.013
1/2	.5070	.4930	.014
9/16	.5700	.5550	.015
5/8	.6330	.6170	.016
3/4	.7585	.7415	.017
7/8	.8840	.8660	.018
1	1.0095	.9905	.019
1 1/8	1.1350	1.1150	.020
1 1/4	1.2605	1.2395	.021





DRIVING-WHEEL CENTERS AND SIZES OF TIRES.

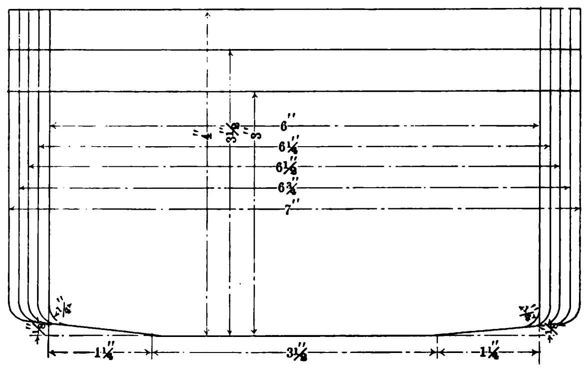
At the Nineteenth Annual Convention the report of a Committee was adopted which recommended driving-wheel centers to be made 38, 44, 50, 56, 62 or 66 inches diameter. At the Twentieth Annual Convention the recommendations of a Committee were adopted making tire gauges manufactured by Messrs. Pratt & Whitney, Hartford, Conn., and here illustrated, standards of the association. The sizes and the allowance for shrinkage are as follows:

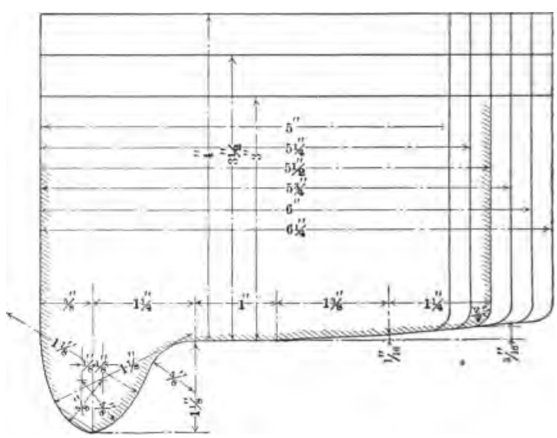


At the Twenty-sixth Annual Convention the following sizes were adopted as standard for large driving-wheels: 70, 74, 78, 82, 86 and 90 inches.

Standard Forms of Tires.

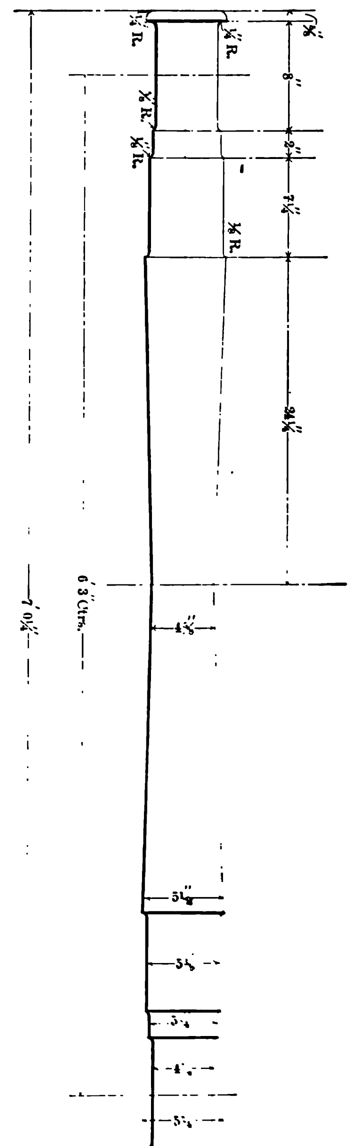
At the Twenty-sixth Annual Convention the forms of tires shown in the annexed engraving were adopted as standard. Railroad companies ordering tires will save time by specifying these forms.





Axle for Heavy Tenders.

The accompanying illustration shows the dimensions of the axle for heavy tenders recommended by a Committee of the association.



Committees for Conducting the Business

FOR THE

YEARS 1893-94.

No. 1. Cracking of Back Tube Sheets.

What method of construction can be devised to prevent the cracking of tube sheets?

T. B. PURVES,
J. M. BOON,
R. C. BLACKALL,
DAVID BROWN,
JOHN MACKENZIE,
L. R. POMEROY.

No. 2. Oiling Devices for Long Runs.

What devices can be provided for locomotives to supply lubrication on long runs?

J. DAVIS BARNETT,
JOHN D. CAMPBELL,
GEO. W. STEVENS,
GEO. W. WEST,
C. E. SMART,
W. D. CROSMAN.

No. 3. Locomotive Fire Kindlers.

Best methods of starting fires in locomotives and their relation to insurance risks.

JOHN HICKEY,
A. PATTEE,
GEO. B. BROOKE,
W. McINTOSH,
W. T. REED,
JOHN A. HILL.

No. 4. Exhaust Nozzles and Steam Passages.

ROBERT QUAYLE,
WM. FORSYTH,
JAMES MCNAUGHTON,
JAS. W. HILL,
W. S. MORRIS,
D. L. BARNES.

No. 5. Boiler and Firebox Steel.

To report on standard specifications and tests for boiler and firebox steel for adoption by the association.

A. W. GIBBS,
G. R. HENDERSON,
J. A. LAWES,
WM. FORSYTH,
E. M. ROBERTS,
W. D. CROSMAN.

No. 6. Sanding Devices.

O. STEWART,
F. M. TWOMBLY,
L. M. BUTLER,
C. E. FULLER,
JOHN MEDWAY,
H. P. ROBINSON.

No. 7. Special Shop Tools.

To report on new or improved appliances, either hand, power, pneumatic, hydraulic or electric, applied or applicable to locomotive manufacture and repair.

T. W. GENTRY,
GEO. L. POTTER,
H. D. GORDON,
G. R. JOUGHINS,
WM. SWANSTON,
F. B. MILES.

No. 8. Standard Tests of Locomotives.

(Continued from last year.)

J. N. LAUDER,
GEO. GIBBS,
P. LEEDS,
R. H. SOULE,
ANGUS SINCLAIR,
F. W. DEAN.

No. 9. Tire Treatment.

What is the amount of shrinkage to be allowed for large driving-wheels? Is there any necessity for retaining rings or clips? What is the limit of thickness tires should be worn down to? What is the greatest permissible depth of groove on tire-tread before turning?

A. E. MITCHELL,
G. W. WEST,
THOS. MILLEN,
J. H. MCCONNELL,
A. J. CROMWELL,
JOHN Y. SMITH.

No. 10. Cost of Maintaining Locomotives.

Report on the comparative cost for repairs of locomotives built in contract shops and those built in railroad shops.

G. W. RHODES,
JACOB JOHANN,
W. SMITH,
J. N. BARR,
WM. GARSTANG,
W. H. MARSHALL.

Obituary Notices.

SUBJECT.	COMMITTEE.
N. E. CHAPMAN......	L. R. POMEROY, J. N. LAUDER, GEO. W. STEVENS.
JOSEPH S. PORTER..	WM. SWANSTON, WM. GARSTANG.

Obituary Notices—continued.

SUBJECT.	COMMITTEE.
H. L. LEACH	H. L. LEACH, JR., GEO. RICHARDS, JOHN THOMPSON.
DAVID PRESTON	R. ATKINSON.
ISAAC DRIPPS	JOHN A. HILL, R. WELLS, F. D. CASANAVE.
A. T. WOODS	D. A. BARNES, GEO. GIBBS, WM. FORSYTH.
CHARLES R. PEDDLE	G. H. PRESCOTT.
JOHN BLACK	C. H. CORY.
L. C. BRASTON	W. MONTGOMERY.
E. J. WHITTINGTON	ANGUS SINCLAIR.
BASIL MANLEY	B. R. HARDING.
S. W. WAKEFIELD	A. L. STUDER.
MATT. ELLIS	JOHN J. ELLIS.
JOHN ORTTON	W. I. COOKE.

Several committees failed to send in notices.

Application for Associate Membership.

	COMMITTEE.
WILLIS C. SQUIRE	W. MCINTOSH, W. H. LEWIS, WM. FORSYTH.

Committee on Subjects for Investigation.

GEO. GIBBS, WM. SMITH,
J. DAVIS BARNETT.

Delegates to American Society of Railway Superintendents' Convention.

J. N. LAUDER,
JOHN MACKENZIE.

Executive Committee.

JOHN HICKEY, R. C. BLACKALL,
WM. GARSTANG, O. STEWART,
ANGUS SINCLAIR.

Names and Addresses of Members.

JOINED.	NAME.	ROAD.	ADDRESS.
1888	Addis, J. W	Texas & Pacific	Gouldsboro, La.
1890	Agnew, J. H		114 North Main st., Findlay, O.
1887	Aldcorn, Thos		New Durham, N. J.
1892	Allen, G. S	Phil. & Reading	Tamaqua, Pa.
1886	Ames, L.	Beech Creek	Jersey Shore, Pa.
1892	Anderson, J. J	Central of Georgia	Savannah, Ga.
1892	Antz, Oscar	L. S. & M. S	Cleveland, O.
1887	Arp, W. C	P. C. C. & St. L	Dennison, O.
1890	Atkinson, R	Canadian Pacific	Montreal, Que.
1887	Augustus, W	Keokuk & Western	Centerville, Ia.
1886	Austin, W. L		Baldwin Loco. Works, Philadelphia, Pa.
1889	Ball, A. W	N. Y. L. E. & W	Galion, O.
1892	Ball, A. J	C. S. & Hocking	Columbus, O.
1888	Barnes, J. B	Wabash	Springfield, Ill.
1892	Barnett, A. R	B. & M	Boston, Mass.
1877	Barnett, J. Davis	Grand Trunk	Stratford, Ont.
1886	Barnett, T. E	Canadian Pacific	Vancouver, B. C.
1890	Barr, J. N	C. M. & St. P	Milwaukee, Wis.
1890	Barnum, M. K	Union Pacific	North Platte, Neb.
1889	Battye, John E	N. & W.	Shenandoah, Va.
1885	Bean, John	C. & Canton	Canton, O.
1889	Bean, S. L	Northern Pacific	Fargo, N. Dak.
1892	Beattie, A. L	New Zealand Govern	Wellington, N. Z.
1892	Bechhold, H. G		Clev. Frog & Crossing Co., Cleveland, O.
1885	Beckert, Andrew	L. & Nashville	Decatur, Ala.
1892	Beltz, A. J	Del., Sus. & Schuylkill	Drifton, Pa.
1892	Benson, A. E	Ulster & Delaware	Rondout, N. Y.
1891	Berry, J. H	C. C. C. & St. L	Delaware, O.
1892	Billingham, Jos		Conemaugh, Pa.
1879	Bisset, John	W. W. C. & A	Wilmington, N. C.
1872	Blackall, R. C	D. & H. Canal Co	Albany, N. Y.
1883	Blackwell, Chas	Mount Lookout	Cincinnati, O.
1887	Boatman, F. P		

JOINED.	NAME.	ROAD.	ADDRESS.
1893	Bond, I	N. Y., L. E. & W	Hornellsville, N. Y.
1869	Boon, J. M	West Shore	Frankfort, N. Y.
1890	Boyle, Wilson L	W. Albany Mach. Shops	West Albany, N. Y.
1890	Bradford, J. C	R. I. Loco. Works	Providence, R. I.
1888	Bradley, W. F	T. A. A. & N. M	Owosso, Mich.
1892	Brehn, W. H	M. K. & T	Parsons, Tex.
1879	Briggs, R. H	K. M. C. & B	Memphis, Tenn.
1887	Brooke, Geo. B	St. P. & Duluth	St. Paul, Minn.
1890	Brown, Angus	Northern Pacific	Livingston, Mont.
1892	Brown, David	D. L. & W	Scranton, Pa.
1887	Brown, F. R. F	Intercolonial Ry	Moncton, N. B.
1891	Brown, J. L	P. & Western	Allegheny, Pa.
1891	Brown, W. A	A. & Danville	Portsmouth, Va.
1882	Brownell, F. G		Muncie st., Muncie, Ind.
1891	Bruce, Frank	Mont. Central	Great Falls, Mont.
1890	Bruck, Henry T	C. & Penn	Mt. Savage, Md.
1882	Bryan, H. S	D. & I. Range	Two Harbors, Minn.
1890	Bryant, J. T	R., F. & P	Richmond, Va.
1893	Buckalew, J. H	Mem. & Charleston	Memphis, Tenn.
1887	Buchanan, Wm	N. Y. C. & H. R	New York City.
1891	Burns, C. H	Hous. & Tex. Cent	Houston, Tex.
1870	Bushnell, R. W	B. C. R. & N	Cedar Rapids, Ia.
1893	Butcher, Geo. W	Texas & New Orleans	Houston, Tex.
1861	Butler, L. M.	N. Y. P. & B	Providence, R. I.
1890	Butterly, T. E	Wabash	Moberly, Mo.
1883	Campbell, John	Lehigh Valley	Delano, Pa.
1891	Campbell, John D	N. Y. Cent	Depew, N. Y.
1889	Carmody, T	N. Y. L. E. & W	Cleveland, O.
1885	Carson, M. T	Mobile & Ohio	Jackson, Tenn.
1889	Casanave, F. D	Penn. R. R	Altoona, Pa.
1890	Casey, J. J	L. N. O. & Tex	Vicksburgh, Miss.
1892	Chamberlain, E	Rood & Brown	Lancaster, N. Y.
1893	Chambers, Jno. S	Ill. Central	Amboy, Ill.
1878	Chapman, T. L	Orange Street	East Orange, N. J.
1893	Childs, H. A	N. Y. L. E. & W	Jersey City, N. J.
1870	Clark, David	Lehigh Valley	Hazelton, Pa.
1886	Clark, Isaac W	C. F. & Y. V	Fayetteville, N. C.
1893	Cleaver, F. C	Vandalia	Terre Haute, Ind.
1892	Clifford, C. J	C. & B. Y	South Chicago, Ill.
1887	Clifford, J. G	L. & Nashville	Mobile, Ala.
1887	Cloud, John W	Rookery Building	Chicago, Ill.
1891	Cockfield, Wm	Mexican Central	Jimulco, Mex.
1885	Collier, M. L	W. & Atlantic	Atlantic, Ga.
1891	Collinson, James	A., T. & S. F	Fort Madison, Ia.

JOINED.	NAME.	ROAD.	ADDRESS.
1890	Conolly, J. J.	D., S. S. & A.	Marquette, Mich.
1892	Conroe, I.	A., T. & S. F.	La Junta, Col.
1892	Cooley, M. W.	Southern Pacific	Fresno, Cal.
1892	Cooper, Charles G.	Toledo, Col. & Cin.	Kenton, O.
1892	Cooper. H. A.	N. Y., L. E. & W	Hornellsville, N. Y.
1879	Cook, John S.	Georgia	Augusta, Ga.
1879	Cooke, Allen	Ch. & E. Ill	Danville, Ill.
1891	Cooke, W. I.	Tol. & St. L. & K. C	Frankfort, Ind.
1888	Cory, C. H.	C. H. & D	Lima, O.
1892	Coxe, Daniel	Del., Sus. & Schuylkill	Drifton, Pa.
1892	Crawford, S. B.	B. & O	Mt. Clare, Balt., Md.
1885	Cromwell, A. J.	B. & O	Baltimore, Md.
1893	Cross, W.	Can. Pac. Ry	Winnipeg. Man.
1883	Cullen, Jas.	N. C. & St. L	Nashville, Tenn.
1889	Curran, Peter	N. Y. L. E. & W.	Bradford, Pa.
1892	Cushing, G. W.		Evanston, Ill.
1892	Dailey, J. B.	Rio Grande West	Salt Lake City, Utah.
1888	Dallas, Wilber C		920 Forrest st., St. Paul. Minn.
1890	Davies, J. M	Chateaugay	Lyon Mt., N. Y.
1892	Davis, Ed. E.		Boies Car Wheel Works, Scranton, Pa.
1886	Davis, Jas. A.	N. T. & Q.	Deseronto, Ont.
1893	Davis, W. J.	Pitts. & Western	Foxbury, Pa.
1891	Deems, J. F	C. B. & Q	Ottumwa, Ia.
1892	Dehn, F. H.	Tex. Cent	Walnut, Tex.
1889	Deibert, F. W.	Ch. M. & St. P.	Portage, Wis.
1893	Derby, Abram	South Florida	Sanford, Fla.
1890	Derby, R	South Florida	Sanford, Fla.
1887	Dickson, G. L.		Dickson Loco. Works, Scranton, Pa.
1887	Dickson, J. P.		Dickson Loco. Works, Scranton, Pa.
1890	Dolbeer, Alonza		Rochester, N. Y.
1882	Domville, C. K	Grand Trunk	Hamilton, Ont.
1892	Dorsey, J. B.	Ohio River	Parkersburg, W. Va.
1880	Dotterer, D. H.		Vacuum Oil Co., Rochester, N. Y.
1890	Downing, T.	El. Jol. & Eastern.	Joliet, Ill.
1889	Durrell, D. J.		Ill. Steel Co., Joliet, Ill.
1881	Eastman, A. G.		Sutton, Que.
1868	Eddy, W. H.		Springfield, Mass.
1869	Elliott, Henry		E. St. Louis, Ill.
1893	Ellis, John J.	C. St. M. & O.	St. Paul, Minn.
1893	Elordi, Juan J.	P. Rys of Buenos Ayres	La Plata, Argent.
1893	Elwell, J. B	East Louisiana	New Orleans. La.
1893	English, Richard	A. & Pac	Albuquerque, N. M.
1881	Ennis, W. C	N. Y. S. & W.	Wortendyke, N. J.
1892	Esson, R. C	So. Pacific	Newark, Cal.

JOINED.	NAME.	ROAD.	ADDRESS.
1885	Fenwick, A	G. B. W. & St. P	Green Bay, Wis.
1885	Ferguson, G. A	Concord & Montreal.	Lakeport, N. H.
1889	Ferry, F. J	L. St. L. & Tex	Cloverport, Ky.
1874	Finlay, L		902 W. 4th st., Little Rock, Ark.
1892	Fitzmorris, James		Union Stock Yards, Chicago, Ill.
1888	Forsyth, Wm	C. B. & Q	Aurora, Ill.
1875	Foster, W. A		Fall Brook Coal Co., Corning, N. Y.
1890	Foulks, John	T. St. L. & K. C	Charleston, Ill.
1877	Fowle, I. W	Col. Midland	Leadville, Col.
1887	Fraser, T. A		Wells & French Car Works, Chicago, Ill.
1891	French, R. F	So. Pacific	Bakersfield, Cal.
1890	Fuller, C. E	Central Vermont	St. Albans, Vt.
1872	Fuller, Wm		213 Kennard st., Cleveland, O.
1891	Galbraith, R. M	St. L., A. & Tex	Tyler, Tex.
1885	Galloway, A	T. A. A. & N. M	Owosso, Mich.
1890	Garlock, W. H	S. L. S. & E	Seattle, Wash.
1883	Garrett, H. D	Penn	Philadelphia, Pa.
1892	Garrison, C. E	West Shore	E. Buffalo, N. Y.
1887	Garstang, Wm	C. C. C. & St. L	Indianapolis, Ind.
1886	Gentry, T. W	Rich. & Dan	Richmond, Va.
1883	George, Nathan M		Danbury, Conn.
1890	Gessler, Wm	C. R. I. & P	Trenton, Mo.
1888	Gibbs, A. W	Pennsylvania	Altoona, Pa.
1890	Gibbs, George	C. M. & St. P	Milwaukee, Wis.
1892	Giles, C. F	L. & Nash	Pensacola, Fla.
1891	Gillis, H. A	Nor. & Western	Roanoke, Va.
1883	Gilmore, W. L	L. S. & M. S	Elkhart, Ind.
1890	Givan, F. A		Penn. Lumber Co., Philadelphia, Pa.
1891	Glass, John C	Allegheny Valley	Verona, Pa.
1891	Gleasier, T. W	Mexican Central	Silao, Mex.
1891	Glover, J. B	Marietta & Nor. Ga	Marietta, Ga.
1880	Gordon, H. D		Juniata Shops, Altoona, Pa.
1879	Gordon, Jas. T	Concord	Concord, N. H.
1891	Gould, Amos	N. Y. C. & H. R	E. Buffalo, N. Y.
1869	Graham, Charles		Scranton, Pa.
1892	Graham, Charles, Jr.	D., L. & W.	Kingston, Pa.
1882	Graham, J. S	L. S. & M. S	Cleveland, O.
1892	Gray, Robert	Southern Pacific	Tucson, Ariz.
1889	Greatsinger, J. L	D. & I. Range	Two Harbors, Minn.
1892	Green, Joseph H	R. & Danville	Columbia, S. C.
1891	Griffin, R. F	D. & I. Range	Two Harbors, Minn.
1885	Griffith, Fred. B	Del., L. & W	Buffalo, N. Y.
1872	Griggs, Albert		15 Wayland st., Dorchester, Mass.
1893	Gross, R. J		Brooks Locomotive Works, Dunkirk, N. Y.

JOINED.	NAME.	ROAD.	ADDRESS.
1880	Hackney, Clem		624 Washington st., Milwaukee, Wis.
1875	Haggett, J. C.	D. & A. Valley	Dunkirk, N. Y.
1886	Haggerty, G. A.	Canadian Pacific	McAdams Junc., N. B.
	Hainen, R. J.	N. Y., L. E. & W.	Port Jervis, N. Y.
1889	Hall, Don Diego	Government Railways	Santiago, Chile.
1883	Hall, J. N		Montgomery, Ala.
1890	Haller, W. J	Ches. & Ohio	Covington, Ky.
1891	Hancock, Geo. A.	Gulf Col. & S. Fé	Galveston, Tex.
1893	Hancock, Wm. T., Jr.	A. & Pacific	Needles, Cal.
1893	Hardie, Jas		Hardie & Co., Valparaiso, Chile.
1875	Harding, B. R.	R. G., R. & A	Raleigh, N. C.
1888	Harrington, John	Mex. Nor	Escalon, Mex.
1888	Harris, Geo. D.	Georgia Southern	Macon, Ga.
1885	Harrison, W. H.	B. & O.	Newark, O.
1889	Haskell, B.	C. & W. Mich	Grand Rapids, Mich.
1888	Hassman, Wm.		
1875	Hatswell, T. J.	F. & P. M	E. Saginaw, Mich.
1888	Hazelton, G. H.	R. W. & O.	Oswego, N. Y.
1890	Hazlehurst, G. B.	B. & O	Baltimore, Md.
1891	Hedley, E. M.	Brooklyn Elevated	Brooklyn, N. Y.
1891	Hedley, F.	Lake Street Elevated	Chicago, Ill.
1888	Hemphill, W. J.	Jacks. So. Eastern	Jacksonville, Ill.
1886	Hendee, A.		Westinghouse Air Brake Co., Pittsburg, Pa.
1892	Henderson, G. R.	Norfolk & Western	Roanoke, Va.
1882	Henney, J. B		93 Bird st., Boston, Mass.
1887	Heintzleman, T. W.	So. Pac.	Sacramento, Cal.
1892	Herr, Edwin M		Grant Loco. Wks., Chicago, Ill.
1877	Hewitt, John		1323 So. Jefferson ave., St. Louis, Mo.
1883	Hickey, John	Nor. Pac.	St. Paul, Minn.
1890	Higgins, S.	N. Y. P. & O.	Cleveland, O.
1887	Hill, Jas. W.	Peoria & Pekin Union	Peoria, Ill.
1892	Hill, Rufus.	Penn.	Pavonia, N. J.
1892	Hincley, A. C.	St. Jo. & Gr. Island	St. Joseph, Mo.
1885	Hinman, M. L		Brooks Loco. Works, Dunkirk, N. Y.
1870	Hodgman, S. A.		Lobdell Car Wheel Co., Wilmington, Del.
1883	Hoffecker, W. L.	Cent. of N. J.	Elizabethport, N. J.
1892	Holland, W. D.	Guatemala, Nor.	Puerto Barrios, G'ala.
1885	Holman, W. L.	Penn.	Renova, Pa.
1890	Homer, John C.		Sta. C., Totton place, Cincinnati, O.
1892	Howard, C. H.		Safety Car Heating Co., 160 Broadway, N. Y.
1890	Hudson, E. E	C. C. C. & St. L.	Cleveland, O.
1892	Hudson, W. H.	E. T. V. & Ga.	Atlanta, Ga.
1890	Hufsmith, F.	T. & G. N.	Palestine, Tex.
1890	Humphrey, A. L.	Col. Mid.	Colorado City, Col.
1892	Hunt, G. H.	So. Pac.	Wadsworth, Nev.

JOINED.	NAME.	ROAD.	ADDRESS.
1889	Irby, Chas.	Current River.	Willow Springs, Mo.
1888	Jackson, O. H		Brightwood, Ind.
1883	Jacques, Richard	Hemenway & Brown, 87 Milk st., Boston, Mass.	
1892	Jenks, E. E	Penn., P. & Boston	Pen Argyl, Pa.
1892	Jennings, G. W	Mex. Cent	City of Mexico, Mex.
1890	Jennings, Wm	Mex. Inter	Piedras Negras, Mex.
1893	Jerome, E. W.	Zanes. & Ohio	Zanesville, O.
1878	Johnson, J. B	A. Midland	Helena, Ark.
1887	Johnson, L. R.	Can. Pacific	Vancouver, B. C.
1887	Johnstone, F. W.	Mexican Central	City of Mexico.
......	Jones, W. H	Ches. & Ohio	Richmond, Va.
1888	Joughins, G. R.	Nor. So.	Berkley, Va.
1892	Keegan, Jas. E.	C. R. & I.	Grand Rapids, Mich.
1892	Keeler, Sanford	F. & P. M	E. Saginaw, Mich.
1887	Kells, Leroy	P. C. & St. L.	Cincinnati, O.
1890	Keith, J. M.	West. R'y of Guatemala	Retalhuleu, Guat.
1882	Kiehner, John I.		2341 E. York st., Philadelphia, Pa.
1888	Kiley, M. R.		
1890	Killen, W. E.	Nev. Cent.	Battle Mt., Nev.
1887	Kimball, N. S.	M. & Nor.	Green Bay, Wis.
1868	Kinsey, J. I.	Lehigh Valley	Easton, Pa.
1892	Kirk, John	A. T. & S. F.	Arkansas City, Kan.
1892	Kissler, Lewis	D. L. & W.	Syracuse, N. Y.
1890	Knapp, G.	H. & Shen.	Shenandoah, Ia.
1891	Kredell, R. F.		Chester, Va.
1890	Kulbaugh, I. N.	B. & O	Pittsburg, Pa.
1891	Lamby, T. L.	T., St. L. & K. C.	Delphos, O.
1873	Lannan, Wm.	House of Representatives, Washington, D. C.	
1888	Lape, C. F	Wabash	Springfield, Ill.
1882	Lape, J. K.	K C. W. & G.	Lake Charles, La.
1870	Lauder, J. N.	Old Colony	Boston, Mass.
1889	Lavery, W.	N. Y. L. E. & W.	Susquehanna, Pa.
1891	Lawler, F. M.	C. C. C. & St. L	Mattoon, Ill.
1891	Lawes, T. A	C. C. C. & St. L.	Indianapolis, Ind.
1890	Leach, H. L.	Fitchburg	Fitchburg, Mass.
1892	Lee, C. W	R. & Danville	Salisbury, N. C.
1883	Leeds, Pulaski	L. & Nash	Louisville, Ky.
1888	Leigh, F. J.		Can. Loco. Works, Kingston, Ont
1890	Leonard, A. G.	N. Y. Central	New York City.
1873	Lewis, W. H.	D. L & W.	Kingsland, N. J.
1890	Lewis, Wm. H.	C. B. & Nor.	La Crosse, Wis.
1890	Lloyd, T. J.	Ches. & Ohio	Richmond, Va.

JOINED.	NAME.	ROAD.	ADDRESS.
1890	Logan, P. A	Can. Eastern	Gibson, N. B.
1892	Lord, E. P		Porter Loco. Works, Pittsburg, Pa.
1868	Losey, Jacob		Steam Forge Co., Louisville, Ky.
1890	Luttgens, H. A		Rogers Loco. Works, Paterson, N. J.
1890	Luttrell, J. W	Ill. Central	Chicago, Ill.
1885	Lythgoe, Jos		R. I. Loco. Works, Providence, R. I.
1887	Macbeth, Jas	N. Y. Central	Buffalo, N. Y.
1892	Macdonald, A.V.,	Hurunui Bluff, Sec. N. Z. Rys.,	Christchurch, N. Z.
1890	Macfarlane, T. W	Nor. Pac	Mandan, N. Dak.
1886	Mackenzie, John	N. Y. C. & St. L	Cleveland, O.
1892	Mackinnon, Geo	Can. Pac	Farnham, Ont.
1878	Maglenn, Jas	Carolina Central	Laurenburg, N. C.
1893	Manning, J. H.	Union Pac	Omaha, Neb.
1891	Manuell, Geo	Mobile & Ohio	Jackson, Tenn.
1890	Marshall. E. S		Madison Car Works, Madison, Ill.
1888	Mayer, A. A	Gr. Trunk	Stratford, Ont.
1889	May, Edward	Intercolonial	Moncton, N. B.
1892	McCann, Thos	Georges Creek & Cum	Cumberland, Md.
1892	McCarthy, J. C	N. O. & N. E	Meridian, Miss.
1891	McClurg, John	C. C. C. & St. L	Urbana, Ill.
1891	McConnell, J. H	Union Pac	Omaha, Neb.
1890	McCormick, J. H	C. & P. Sound	Seattle, Wash.
1893	McCracken, J. E	K. C. O. & S	Sheffield, Mo.
1890	McCreery, Frank	C. H. & D	Dayton, O.
1875	McCrum, J. S	K. C. Ft. S. & G	Kansas City, Mo.
1892	McCuen, J. P	Ala. Gr. Southern.	Birmingham, Ala.
1892	McGee, F. H	Cent. of Ga	Macon, Ga.
1889	McGrayel, John		Grand Junction, Ia.
......	McDonough, Jas	Gulf, Col. & S. F	Galveston, Tex.
1892	McDuff, Allan	B. C. R. & N	Cedar Rapids, Ia.
.....	McElvaney, C. T	M. K. & Tex	Dennison, Tex.
1892	McIlwain, J. D		Harvey Steel Car Wks., Chicago, Ill.
1890	McIntosh, Wm	Ch. & N. Western	Winona, Minn.
1893	McKee, G. S	C. C. C. & St. L.	Mattoon, Ill.
1891	McKenna, John	I. D. S	Indianapolis, Ind.
1890	McNaughton, Jas	Wis. Cent	Waukesha, Wis.
1888	McNiven, P. C		Can. Loco. Wks., Kingston, Ont.
1888	Medway, John	Fitchburg	Boston, Mass.
1883	Meehan, Jas	C. N. O. & T. P	Ludlow, Ky.
1892	Mertsheimer, F	Union Pacific	Cheyenne, Wyo.
1887	Michael, J. B	E. T. V. & G	Knoxville. Tenn.
1883	Middleton, Harvey		Pullman Shops. Pullman, Ill.
1889	Midelton, Thos		Sydney, N. S. W.
1885	Millen, Thos	N. Y. C. & N	High Bridge, N. Y.

JOINED.	NAME.	ROAD.	ADDRESS.
1891	Miller, W. H		
1890	Miller, Geo. A	J. St. A. & H.	St. Augustine, Fla.
1889	Miller, E. A	N. Y. C. & St. L.	Conneaut, O.
1890	Mills, Stott.	Lehigh & Hudson	Warwick, N. Y.
1893	Minshull, P. H.	N. Y. O. & W.	Middleton, N. Y.
1892	Minto, H. M	L. & Nash	Mobile, Ala.
1888	Minton, A. B.	Mobile & Ohio	Murphysboro, Ill.
1892	Mitchell, Alva	A. T. & S. F.	Ottawa, Kan.
1870	Mitchell, A.	Lehigh Valley	Wilkesbarre, Pa.
1892	Mitchell, A. E.	N. Y., L. E. & W.	New York City.
1890	Monkhouse, H	C., R. I. & P	Horton, Kan.
1888	Montgomery, Wm	Cent. of N. J.	Manchester, N. J.
1890	Moore, J. H.	N. Y., L. E. & W.	Elmira, N. Y.
1882	Morrell, J. E	C., R. I. & P.	Davenport, Ia.
1887	Morris, W. S.	Ches. & Ohio	Richmond, Va.
1890	Morse, F. W	Wabash	Ft. Wayne, Ind.
1876	Morse, G. F	Portland Loco. Works,	Portland, Me.
1890	Morse, W. M	T. & O. C. E.	Marietta, O.
1891	Mott, D. G	Panama	Colon, Colombia.
1893	Mottershead, Peter	Ch. & N. Western	Boone, Ia.
1890	Murphy, P. H.	Murphy Car Roof Co.,	East St. Louis, Ill.
1892	Nauffer, John G.	B. O. & S. W	Chillicothe, O.
1890	Nicholls, J. Mayne	Ferro Caril	Iquique, Chile.
1875	Noble, L. C	A. French Spring Co.,	Pittsburg, Pa.
1890	O'Brien, John	Rich. & Petersburg	Manchester, Va.
1892	O'Brien, Geo. W	Cent. of Ga	Augusta, Ga
1890	O'Herin, Wm	Mo., Kan. & Tex	Parsons, Kan.
1891	O'Keefe, Geo. A	Det., Lan. & Nor	Ionia, Mich.
1892	Ott, Geo. R	B. & O	Garrett, Ind.
1890	Page, H. D	Ch. & N. Western	Baraboo, Wis.
1891	Papineow, F. G	So. Pac	Houston, Tex.
1891	Pattee, J. O.	Gr. Nor	St. Paul, Minn.
1879	Patterson, J. S.		523 Phœnix Bldg., Chicago, Ill.
1885	Paxson, L. B.	P. & Reading	Reading, Pa.
1891	Paxton, Thos	A. T. & S. F.	Nickerson, Kan.
1887	Peck, Peter H.	C. W. I. & B	Chicago, Ill.
1890	Petriken, C. L	Union Iron Works Co.,	Selma, Ala.
1868	Perry, F. A	Cheshire	Keene, N. H.
1889	Phelan, J. E	Nor. Pac	Dickinson, Dak.
1878	Pilsbury, Amos	Maine Cent.	Waterville, Me.
1885	Pitkin, A. J	Schenectady Loco. Wks.,	Schenectady, N. Y.

JOINED.	NAME.	ROAD.	ADDRESS.
1874	Place, T. W	Ill. Cent	Waterloo, Ia.
1881	Player, John	A. T. & S. F.	Topeka, Kan.
1893	Potter, G. S.	Penna. Lines	Ft. Wayne, Ind.
1873	Prescott, G. H.	T. H. I. & St. L.	Terre Haute, Ind.
1891	Prescott, C. H	Spokane Falls & Nor.	Spokane Falls, Wash.
1890	Price, Wm. D	P. A. & Western	Delphos, O.
1892	Priest, H. F.	Duluth, Missabe & Nor.	Duluth, Minn.
1881	Pringle, R. M.		1101 North Second st., St. Louis, Mo.
1891	Pullar, John	A. & Pacific	Winslow, Ariz.
1890	Purves, T. B., Jr.	B. & A	E. Albany, N. Y.
1892	Putnam, G. V	F. S. & G	Gloversville, N. Y.
1887	Quackenbush, A. W.	St. L. Cape G. & Ft. S.	Cape Girardeau, Mo.
1888	Quayle. Robert.	M. L. S. & W.	S. Kaukauna, Wis.
1888	Quinn, John A.	C. V. & C	Mt. Carmel, Ill.
1890	Ramsay, J. C	Ill. Central	Memphis, Tenn.
1890	Randolph, L. S.	Baltimore Electric Refining Co.,	Baltimore, Md.
1889	Ranson, T. W		629 Lake st., Cleveland, O.
1891	Rearden, Frank	Missouri Pac.	St. Louis, Mo.
1892	Redding, R. E.	Elevated	New York.
1888	Reed, W. T.	Ch. St. P. & K. C.	St. Paul, Minn.
1890	Reid, M. M	Nor. So.	Berkley, Va.
1890	Reiley, B.	Minn. & St. L.	Minneapolis, Minn.
1890	Remex, B. H. de.	D. & R. G.	Leadville, Col.
1883	Renshaw, W.	Ill. Cent	Chicago, Ill.
1892	Rettew, C. E.	D. & H. C.	Carbondale, Pa.
1887	Reynolds, W. W.	C. St. L. & P.	Columbus, O.
1888	Rhodes, G. W.	C. B. & Q	Aurora, Ill.
1883	Richardson, E.	S. & Allegheny	Greenville, Pa.
1889	Rickard, C. W.	A. T. & S. F.	Raton, N. M.
1890	Riley, G. M. D.	Sav., Fla. & Western.	Savannah, Ga.
1882	Roberts, E. M	E. T. V. & G.	Charleston, S. C.
1891	Roberts, Wood.	St. L. I. M. & S.	Little Rock, Ark.
1885	Robertson, W. J.	C. Vermont	St. Albans, Vt.
1890	Robinson, John	L. S. & M. S.	Buffalo, N. Y.
1891	Rogers, M. J.		
1890	Rommel, George.	Wil. & Nor.	Wilmington, Del.
1882	Ross, Geo. B.		Box 326, Buffalo, N. Y.
1892	Rotherham, T. F	New Zealand Gov't.	Wellington, N. Z.
1891	Russell, W. R.	Q. M. & C	Quebec, Can.
1890	Rutherford, Wm	Fla. So	Palatka, Fla.
1892	Ryan, Pat.	L. & Nash.	Russellville, Ky.
1891	Ryan, J. J.	So. Pacific	Houston, Tex.
1891	Ryder, Henry	Housatonic	Falls Village, Conn.

JOINED.	NAME.	ROAD.	ADDRESS.
1892	Sague, J. E	Schenectady Loco. Works	Schenectady, N. Y.
1887	Sample, N. W	D. & R. G	Denver, Col.
1891	Sanborn, J. N	C. M. & St. P	Clinton, Ill.
1890	Savage, R. W	St. L. A. & Tex	Tyler, Tex.
1874	Schlacks, Henry		Chicago, Ill.
1891	Schreiber, P. H	C. N. O. & T. P	Chattanooga, Tenn.
1875	Sedgwick, V. E	Mex. Nat	Tampico, Mex.
1882	Selby, W. H		Box 1503, Moberly, Randolph Co., Mo.
1869	Setchel, J. H		Cuba, N. Y.
1890	Seward, J. P	A. & B. Short Line	Annapolis, Md.
1892	Shackford, C. E	Mex. Cent	San Luis Potosi, Mex.
1890	Shafer, J. C		
1870	Shaver, D. O	Penn	Pittsburg, Pa.
1890	Sheahan, J. F	Orange Belt	Oakland, Fla.
1891	Sheer, Jas. M	Ohio & Miss	Washington, Ind.
1890	Sheerer, E. P	Des Moines Union	Des Moines, Ia.
1890	Shields, J. C	Mineral Range	Hancock, Mich.
1892	Sheppard, S. A	T. & Gulf	Clermont, Fla.
1890	Silvius, E. T	J. St. A. & H. R	St. Augustine, Fla.
1883	Sinclair, Angus		5 Beekman street, New York City.
1892	Sinnott, W	B. & O	58th street, Phila, Pa.
1880	Sitton, J. B	Mex. Nat	Laredo, Tex.
1889	Skinner, H. M. C		2 Walnut street, Fall River, Mass.
1893	Slater, Frank	M. L. S. & West	Kaukauna, Wis.
1892	Slater, J. C	Nev. Central	Battle Mt., Nev.
1889	Small, H. J	So. Pac	Sacramento, Cal.
1887	Small, W. T	B. R. & P	Rochester, N. Y.
1886	Smart, C. E	Mich. Cent	Jackson, Mich.
1893	Smith, F. B	N. Y. P. & O	Meadville, Pa.
1890	Smith, Geo. W	A. T. & S. F	Topeka, Kan.
1892	Smith, John L	N. Y., L. E. & W	Bradford, Pa.
1891	Smith, Wm	Ch. & N. Western	Chicago, Ill.
1869	Smith, W. T	Newport News & M. V	Lexington, Ky.
1891	Soule, R. H	Nor. & Western	Roanoke, Va.
1868	Sprague, H. N		Pittsburg, Pa.
1893	Stalder, A. W	F. Ft. W. & W	Findlay, O.
1890	Stamelen, F	Erie & Huron	Chatham, Ont.
1872	Stearns, W. H	Conn. River	Springfield, Mass.
1887	Stephens, S. A		R. I. Loco. Works, Providence, R. I.
1874	Stevens, Geo. W	L. S. & M. S	Cleveland, O.
1892	Stewart, Andrew F	Ches. & Ohio	Huntington, W. Va.
1885	Stewart O		152 No. avenue, Cambridge, Mass.
1890	Stillman, H	S. D. & S. Pac	Dunsmuir, Cal.
1885	Stinard, F. A		143 Park ave., Paterson, N. J.
1883	Stokes, J. W	St. L. & T. H	E. St. Louis, Ill.

JOINED.	NAME.	ROAD.	ADDRESS.
1887	Stone, W. A	L. E. & St. L	Huntingburg, Ind.
1890	Stout, Henry K.	Penn	Sunbury, Pa.
1875	Strode, Jas.	N. Cent	Elmira, N. Y.
1891	Strom, L.	Sonora	Nogales, Ariz.
1890	Studer, A. L	C. R. I. & P. S	Stuart, Ia.
1883	Sullivan, A. W.	Ill. Cent	Chicago, Ill.
1891	Sullivan, J. J	Louisville So	Harrodsburg, Ky.
1891	Summerskill, T. A.	M. & N. West	Portage, Man.
1892	Sumner, Eben T.	B. & M	E. Cambridge, Mass.
1892	Sutherland, R. D.	Boston, R. B. & Lynn	Boston, Mass.
1868	Swanston, Wm.	C., St. L. & P.	Indianapolis, Ind.
1892	Symons, W. E.	A. T. & S. F.	Raton, N. M.
1893	Tabor, W. G	Da., V. & T.	Dunkirk, N. Y.
1883	Tandy, H.	Brooks Loco. Wks.,	Dunkirk, N. Y.
1886	Thatcher, Thos	D. L. & W.	Utica, N. Y.
1885	Thomas, C. F.	R. & Danville	Alexandria, Va.
1891	Thomas, H. J	D. B. C. & A	E. Tawas, Mich.
1892	Thomas, J. J., Jr.	Birmingham & Atlantic	Talladega, Ala.
1883	Thomas, W. H.	E. T. V. & G.	Knoxville, Tenn.
1890	Thomas, W. J	North P. Coast	Sausalite, Cal.
1890	Thompson, C. A.		Richmond Hill, N. Y.
1883	Thow, Wm.	Government	Sydney, N. S. W.
1892	Todd, Louis C.	B. & M	Lyndonville, Vt.
1892	Tomlinson, Jas. G.	Ala. Gr. So.	Birmingham, Ala.
1893	Tonge, John	M. & St. L.	Minneapolis, Minn.
1885	Torrence, John.	E. & T. H	Evansville, Ind.
1892	Townsend, Jos.	Ch. & Alton	Bloomington, Ill.
1892	Traver, W. H.	A. T. & S. F.	Argentine, Kan.
1883	Tregelles, Henry	Norton, Megaw & Co.,	Rio de J., Brazil.
1892	Tremp, A. E.	Ohio So.	Springfield, O.
1892	Tresize, Thos	B. & O.	Philadelphia, Pa.
1890	Tuggle, S. R.	Kentucky Cent	Covington, Ky.
1890	Turner, Calvin G.	Phil., Wil. & Balt.	Wilmington, Del.
1889	Turner, Chas. E.	W. N. Y. & Pa.	Olean, N. Y.
1886	Turner, J. S.	Eames Vacuum Brake Co.,	New York City.
1890	Turner, L. H	Pitts. & L. Erie	Chartiers, Pa.
1886	Twombly, A. W.	Old Colony	Taunton, Mass.
1883	Twombly, Fred M.	Old Colony	Boston, Mass.
1890	Tyerell, Thos. H.	S. I. R. T	Whitehall st., N. Y.
1887	Tynan, F. F.	Ferro Carriles Unidos de la Habana	Habana, Cuba.
1885	Ulmo, H. A.	C. & Savannah.	Savannah, Ga.
1872	Underhill, A. B.	B. & Albany	Springfield, Mass.
1889	Vail, A.	W. N. Y. & Pa.	Buffalo, N. Y.
1890	Van Brunt, G. E.	Penn. & N. Western	Bellwood, Pa.

JOINED.	NAME.	ROAD.	ADDRESS.
1891	Vauclain, Samuel M	Baldwin Loco. Works	Philadelphia, Pa.
1892	Vogt, Axel	Pennsylvania	Altoona, Pa.
1892	Von Wrede, G. F. H.	Phil. & Reading.	Philadelphia, Pa.
1889	Voss, Wm	Barney & Smith Car Works	Dayton, O.
1892	Wade, R. D	R. & Danville	Washington, D. C.
1892	Waitt, A. M	L. S. & M. S.	Cleveland, O.
1890	Walden, W. A	R. & Danville.	Atlanta, Ga.
......	Walker, A. E	Au Sable & N. W	McKinley, Mich.
1886	Walker, C. W	S. & Roanoke	Portsmouth, Va.
1888	Wall, E. B	Penn. R.R	Chicago, Ill.
1891	Wallace, Andrew	Ariz. & N. M	Clifton, Ariz.
1887	Wallis, Herbert	Gr. Trunk	Montreal, Can.
1891	Wallis, J. M	Pennsylvania	Altoona, Pa.
1888	Wallis, Philip	Nor. & West'n	Roanoke, Va.
1874	Walsh, Thos	L. & Nash	Howell, Ind.
1892	Walsh, Thos	C. N. O. & T. P.	Somerset, Ky.
1886	Wanklyn, F. L	Gr. Trunk	Montreal, Can.
1892	Warburton, Chas. H.	Cleve., Lor. & W	Lorain, O.
1887	Ward, C. F	D. & Winn.	Duluth, Minn.
1892	Warner, S. H	Nor. Pac.	Tacoma, Wash.
1883	Warren, Beriah	T. P. & W	Peoria, Ill.
1882	Warren, W. B		2827 Caroline st., St. Louis, Mo.
1890	Warwick, T. F	C. of Ga	Augusta, Ga.
1883	Watts, Amos H	C. J. & M	Marshall, Mich.
1887	Webb, F. W	L. & N. W	Crewe, England.
1890	Webb, M. S	M. & Phœnix	Phœnix, Ariz.
1892	Weiss, C. R	N. Y. L. E. & W	Rochester, N. Y.
1886	Weisgerber, E. L	B. & O	Newark, O.
1868	Wells, Reuben	Rogers Loco. Wks.	Paterson, N. J.
1880	West, G. W	N. Y. O. & W	Middleton, N. Y.
1885	Wheeler, M. C		Marshalltown, Ia.
1885	White, A. M	Schenectady Loco. Wks.	Schenectady, N. Y.
1890	White, E. P	C. N. & E	Cadillas, Mich.
1885	Whitlock, Joseph	N. H. & D	Ansonia, Conn.
1869	Whitney, H. A		Moncton, N. B.
1884	Wightman, D. A	Pitts. Loco. Works	Allegheny, Pa.
1891	Wilcox, W. J	C. C. C.	Blacksburg, S. C.
1885	Williams, C. G		Communipaw, N. J.
1891	Williams, E. A	M. St. P. S. S. & M.	Minneapolis, Minn.
1885	Williams, R		
1890	Wilson, Ellis D	Nitrate	Pisagua, Chile.
1887	Wilson, G. F	C., R. I. & P.	Chicago, Ill.
1890	Wilson, John		1911 Pinkney st., Omaha, Neb.
1887	Winslow, J. N	Todd Machine Co.	Tacoma, Wash.
1890	Wyman, Jeffries	B. & Mo. River	Alliance, Neb.

Associate Members.

JOINED.	NAME.	ADDRESS.
1893	Baker, George H	Morse Building, New York.
1888	Barnes, D. L	Rookery Building, Chicago, Ill.
1890	Crosman, W. D	Rookery Building, Chicago, Ill.
1883	Dean, F. W	55 State st., Boston, Mass.
1871	Forney, M. N.	501 Fifth ave., New York City.
1880	Gordon, Alex	Niles Tool Works, Hamilton, O.
1889	Hill, John A	912 Temple Court, New York City.
1881	Hill, John W	Glenn Building, Cincinnati, O.
1893	Leeds, Hon. John H	318 Howard ave., New Haven, Conn.
1891	Marshall, W. H	Rookery Building, Chicago, Ill.
1871	Miles, F. B	Bement & Miles, Philadelphia, Pa.
1889	Pomeroy, L. R	29 Broadway, New York City.
1893	Robinson, H. P	Monadnock Building, Chicago, Ill.
1886	Shaw, Thos	915 Ridge st., Philadelphia, Pa.
1889	Smith, John Y	Doylestown, Pa.
1882	Smith, W. A	Rookery Building, Chicago, Ill.
1871	Wheelock, Jerome	25 Elizabeth st., Worcester, Mass.

Honorary Members.

JOINED.	NAME.	ROAD.	ADDRESS.
1869	Coolidge, G. A		Charlestown, Mass.
1870	Cooper, H. L		4644 State st., Chicago, Ill.
1870	Divine, J. F.	W. & Weldon	Wilmington, N. C.
1868	Eddy, Wilson		Springfield, Mass.
1872	Foss, J. M	Cent. Vermont	St. Albans, Vt.
1874	Jeffery, E. T	Denver & R. G	Denver, Col.
1868	Johann, Jacob		Springfield, Ill.
1868	Mulligan, J	Conn. River	Springfield, Mass.
1874	Perrin, P. J		Taunton, Mass.
1872	Philbric, J. W		Waterville, Me.
1869	Richards, George		14 Auburn street, Roxbury, Mass.
1870	Robinson, W. A		Hamilton, Ont.
1869	Sellers, Morris		Phœnix Building, Chicago, Ill.
1888	Sheppard, F. L	Pennsylvania	Altoona, Pa.
1869	Thompson, John		137 Webster st., East Boston, Mass.
1870	Towne, H. A		236 First ave., Minneapolis, Minn.
1869	White, J. L		Danville, Ill.
1870	Williams, E. H	Baldwin Locomotive Works	Philadelphia, Pa.

Constitution and By-Laws.

ARTICLE I.

NAME.

The name of this association shall be the AMERICAN RAILWAY MASTER MECHANICS' ASSOCIATION.

ARTICLE II.

OBJECTS OF THE ASSOCIATION.

The objects of this association shall be the advancement of knowledge concerning the principles, construction, repair and service of the rolling-stock of railroads, by discussions in common, the exchange of information, and investigations and reports of the experience of its members; and to provide an organization through which the members may agree upon such joint action as may be required to give the greatest efficiency to the equipment of railroads which is intrusted to their care.

ARTICLE III.

MEMBERSHIP.

SECTION 1. The following persons may become active members of the association on being recommended by two members in good standing, signing an application for membership and agreement to conform to the requirements of the Constitution and By-Laws, or authorizing the Secretary to sign the Constitution for them:

1. Those above the rank of general foremen, having charge of the design, construction or repair of railway rolling-stock.

2. General foremen, if their names are presented by their superior officers.

(3.) Two representatives from each locomotive and car-building works.

SEC. 2. Civil and mechanical engineers, or other persons having such a knowledge of science or practical experience in matters pertaining to the construction of rolling stock as would be of special value to the association or railroad companies, may become associate members on being recommended by three active members. The name of such candidate shall then be referred to a Committee, to be appointed by the President, which shall investigate the fitness of the candidate and report to the Executive Committee of the association at the next annual meeting. If the report be unanimous in favor of the candidate the name shall be submitted to ballot, and five dissenting votes shall reject. The number of associate members shall not exceed twenty, and they shall be entitled to all the privileges of active members, excepting that of voting.

SEC. 3. All members of the association, excepting as hereafter provided, shall be subject to the payment of such annual dues as it may be necessary to assess for the purpose of defraying the expenses of the association, provided that no assessment shall exceed five dollars a year.

Such dues shall be payable when the amount thereof is announced by the President, at each annual meeting. Any member who shall be two years in arrears for annual dues, shall be notified of the fact, and if the arrears are not paid within three months after such notification, his name shall be taken from the roll and he be duly notified of the same by the Secretary.

SEC. 4. Any person who has been or may be duly qualified as a member of this association will remain such until his resignation is voluntarily tendered, or he becomes disqualified by the terms of this Constitution. Members whose names have been dropped for non-payment of dues may be restored to membership by the unanimous consent of the Executive Committee on the payment of all back dues.

SEC. 5. Members of the association who have been in good standing for not less than five years, and who through age or other cause cease to be actively engaged in the mechanical department of railway service, may, upon the unanimous vote of the members present at the annual meeting, be elected Honorary

Members. The dues of the Honorary Members shall be remitted, and they shall have all the privileges of active members, except that of voting.

SEC. 6. Any member who, during the meetings of the association, shall be guilty of dishonorable conduct which is disgraceful to a railroad officer and a member of the association, or shall refuse to obey the chairman when called to order, may be expelled by a two-thirds affirmative vote at any regular meeting of the association held within one year from the date of the offense.

ARTICLE IV.

OFFICERS.

SEC. 1. The officers of the association shall be a President, a First Vice-President, a Second Vice-President, a Treasurer and a Secretary, and they shall constitute the Executive Committee.

ARTICLE V.

DUTIES OF OFFICERS.

SEC. 1. It shall be the duty of the President to preside at all the meetings of the association, appoint all Committees—designating the chairman, and approve all bills against the association for payment by the Treasurer.

SEC. 2. It shall be the duty of the Vice-Presidents, according to rank, to perform the duties of the President in his absence from the meetings of the association.

SEC. 3. In case of the absence of both President and Vice-Presidents, the members present shall elect a President *pro tempore.*

SEC. 4. It shall be the duty of the Secretary to keep a full and correct record of all transactions at the meetings of the association; to keep a record of the names and places of residence of all members, and the name of the railway they each represent; to certify to the persons who are eligible as candidates for the association's scholarships at the Stevens Institute of Technology; to receive and keep an account of all money paid to the association and deliver the same to the Treasurer, taking his receipt for the amount; to receive from the Treasurer all paid bills, giving him a receipted statement of the same.

SEC. 5. It shall be the duty of the Treasurer to receive all money from the Secretary belonging to the association; to receive all bills and pay the same, after having approval of the President; to deliver all bills paid to the Secretary at the close of each meeting, taking a receipted statement of the same, and to keep an accurate book account of all transactions pertaining to his office.

ARTICLE VI.

EXECUTIVE COMMITTEE.

SEC. 1. The Executive Committee shall exercise a general supervision over the interests and affairs of the association, recommend the amount of the annual assessment, to call, to prepare for, and to conduct general Conventions, and to make all necessary purchases, expenditures and contracts required to conduct the current business of the association, but shall have no power to make the association liable for any debt to an amount beyond that which at the time of contracting the same shall be in the Treasurer's hands in cash, but not subject to prior liabilities. All expenditures for special purposes shall only be made by appropriations acted upon by the association at a regular meeting.

SEC. 2. The Executive Committee shall receive, examine and approve before public reading, all communications, papers and reports on all mechanical and scientific matters; they shall decide what portion of the reports, papers and drawings shall be submitted to each Convention and what portion shall be printed in the annual report.

SEC. 3. Three members shall constitute a quorum for the transaction of business.

SEC. 4. The Executive Committee shall form with a Committee of the Master Car Builders' Association a Joint Committee to decide on the place of meeting for the Annual Convention.

ARTICLE VII.

ASSOCIATION SCHOLARSHIPS.

It shall be the duty of the Secretary to issue a circular annually intimating the date and place when and where candidates may

be examined for the scholarships of the association in the Stevens Institute of Technology, Hoboken, N. J.

Acceptable candidates for the scholarships are the sons of members of the association in good standing, the sons of honorary members and sons of deceased active or honorary members who may have died while in good standing. Candidates for these scholarships shall apply to the Secretary of this association, and if found eligible shall be given a certificate to that effect for presentation to the school authorities. This will entitle the candidate to attend the preliminary examination. If more than one candidate passes the preliminary examination, the applicant passing the highest examination shall be entitled to the scholarship, the school authorities settling the question.

The candidates for these scholarships must have at least one year's experience in some recognized machine shop. The successful candidate shall also be required to take the course of mechanical engineering.

ARTICLE VIII.

ELECTION OF OFFICERS.

SEC. 1. The officers of the association shall be elected by ballot separately without nomination at the regular meeting of the association, held in June of each year. A majority of all votes cast shall be necessary to an election, and elections shall not be postponed.

SEC. 2. Two tellers shall be appointed by the President to conduct the election and report the result.

ARTICLE IX.

AUDITING COMMITTEE.

SEC. 1. At the first session of the annual meeting an Auditing Committee, consisting of three members not officers of the association, to be nominated by any member who does not hold office, shall be elected in the same way as officers are voted for. This Auditing Committee shall examine the accounts and vouchers of the Treasurer and certify whether they have been found correct or not. After the performance of this duty they shall be discharged by the acceptance of their report by the association.

COMMITTEE ON SUBJECTS FOR INVESTIGATION AND DISCUSSION.

SEC 2. At each annual meeting the President shall appoint a Committee whose duty it shall be to report at the next annual meeting subjects for investigation and discussion, and if the subjects are approved by the association the President, as hereinafter provided, shall appoint Committees to report on them. It shall also be the duty of the Committee to receive from members questions for discussion during the time set apart for that purpose. This Committee shall determine whether such questions are suitable ones for discussion, and if so, they shall so report them to the association.

COMMITTEES ON INVESTIGATION.

SEC. 3. When the Committee on Subjects has reported, and the association approved of subjects for investigation, the President shall appoint special Committees to investigate and report on them, and may authorize and appoint a *special* Committee to investigate and report on any subject which a majority of the members present may approve.

ARTICLE X.

AMENDMENTS.

SEC. 1. This Constitution may be amended at any regular meeting by a two-third vote of the members present, provided that written notice of the proposed amendments has been given at a previous meeting at least six months before.

By-Laws.

TIME OF MEETING.

I. The regular meeting of the association shall be held annually on the Monday after the second Tuesday in June.

HOURS OF SESSION.

II. The regular hours of session shall be from nine o'clock A. M. to two o'clock P. M.

PLACE OF MEETING.

III. Places for holding the Annual Convention shall be selected by a Joint Committee composed of the President, two Vice-Presidents, Secretary and Treasurer of this association, and the President, three Vice-Presidents and Secretary of the Master Car Builders' Association. This Joint Committee shall meet within six months after the Convention and decide upon a place of meeting, the place receiving the largest number of votes to be selected.

QUORUM.

IV. At any regular meeting of the association, fifteen or more members entitled to vote shall constitute a quorum.

ORDER OF BUSINESS.

V. The business of the meetings of this association shall, unless otherwise ordered by a vote, proceed in the following order:

1st. Opening prayer.
2d. Address by the President.
3d. Calling the roll.
4th. Acting on the minutes of the last meeting.
5th. Reports of Secretary and Treasurer.
6th. Assessment and announcement of annual dues.

7th. Election of Auditing Committee.
8th. Unfinished business.
9th. New business.
10th. Reports of Committees.
11th. Reading of papers and discussion of questions propounded by members.
12th. Routine and miscellaneous business.
13th. Election of officers.
14th. Adjournment.

QUESTIONS FOR DISCUSSION, SPECIAL ORDER OF.

VI. Unless otherwise ordered, the discussion of questions proposed by members shall be the special order from 12 o'clock M. to 1 P. M. of each day of the annual meeting.

DECISIONS.

VII. The votes of a majority of the members shall be required to decide any question, motion or resolution which shall come before the association, unless otherwise provided.

DISCUSSIONS.

VIII. No patentees or their agents shall be admitted in the meetings of the association for the purpose of advocating the claims of any patent or patentee, unless by unanimous consent.

IX. No member shall speak more than twice in the discussion of any question until all the other members who want to speak, and have not been heard, have spoken.

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